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Chemical Technology Division

PRELIMINARY ANALYSIS OF THE OAK RIDGE NATIONAL LABORATORY LIQUID LOW-LEVEL WASTE SYSTEM

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1. INTRODUCTION

The objective of this report is to summarize the status of the Liquid Low-Level Waste (LLLW) Systems Analysis project. The focus of this project has been to collect and tabulate data concerning the LLLW system, analyze the current LLLW system operation, and develop the information necessary for the development of long term treatment options for the LLLW generated at ORNL.

The data employed in this report were collected through a survey of ORNL literature, various letter reports, and a survey of all current LLLW generators. The detailed data will be presented in ORNL TM-11250. This data is also being compiled in a user friendly database for ORNL wide distribution. The database will allow the quick retrieval of all information collected on the ORNL LLLW system and will greatly benefit any LLLW analysis effort. This report summarizes the results for the analyses performed to date on the LLLW system.

- Section 2 - a description of the LLLW user friendly database currently under development (all of the following sections have, as their basis, data compiled in the database)
- Section 3 - a brief description of the LLLW system at ORNL
- Section 4 - a detailed description of the activities of the major LLLW generators and a summary of the LLLW generation rates since 1986
- Section 5 - an analysis of the current LLLW system operation
- Section 6 - a presentation of the LLLW system mass balance
- Section 7 - a summary of the future direction of the systems analysis effort and preliminary conclusions.

2. LLLW SYSTEM DATA BASE

A data base has been developed in DBASE III to store, retrieve, and analyze information concerning the LLLW disposal system at ORNL. Menus are being written to enable people who are unfamiliar with DBASE to use the data-base. When completed, the data base will be accessible through a user friendly software program which will not require the presence of DBASE.

The structure of the data base has been previously summarized in a letter report to C. H. Brown, Jr. entitled "Compilation of LLLW Systems Data," dated March 31, 1989. An updated summary document will be prepared in FY-90, and the completion of the data base and accompanying user's manual has been set as an April 1990 Award Fee Milestone. Figure 2.1 shows the basic structure of the menu-driven software that will enable users to retrieve data.

Information contained in the data base includes: (1) LLLW generator information, (2) LLLW collection tank data, (3) evaporator/evaporation data, and (4) LLLW concentrate data. Some analysis of the data will be included as an option from the main menu. This data, in addition to being accessible as a data base, is summarized in the following sections of this report. The data has been extensively analyzed, and thus produced the input for this report.

2.1 LLLW GENERATOR INFORMATION

Generator information has been obtained through the help of the Liquid Generation Certification Officers (LGCOs) who were appointed in March by their divisions to provide data concerning liquid wastes (low level and process) generated in their area. The information from LGCOs contained in the data base includes estimated LLLW generation volumes, waste contaminants (chemical and radioactive), predictions of future waste generation, and waste pretreatment steps currently in use, if any. General descriptions of the activities performed in the areas are also included. Obtaining the data from the LGCOs took approximately four months to complete.

Table 2.1 compares the 1988 dilute LLLW generation rates as reported by the Liquid and Gaseous Waste Group in E&HP Division versus those estimated rates as provided by LGCOs. In addition, the amount of rainwater collected in tanks that were identified as being significantly influenced by rainfall (Sect. 4.2) are included. As Table 2.1 demonstrates, the total monthly volume generation rates compare very favorably particularly when rainfall influence is taken into account. This information, with estimates of radioactive and other contaminates provided by the LGCOs as well as direct sampling

Table 2.1 1988 LLLW Generation Rates: Liquid and Gaseous Waste Operations data vs. generator estimates

Building/Area Served	Tank	1988 monthly average per WOCC (gal)	Generator estimated monthly average (gal)	Rainfall collection for specific tanks (gal/month) (d)
Isotope Area (a)	WC-10	1611	861	
3039 Stack Area	W-22	3275	3275	
Reactors	WC-19	1378	1062	829
Abandoned	W-1A	1161	0	2394
2026	2026 (e)	84	0.5	
4500N,4505,4507	WC-11	594	0	346
4505,4507	WC-12	180	130	
4500N,4500S,4501,4508	WC-13	667	121	
4501	WC-14	163	41	
3517	W-22 & W-12	3150	2836	513
Pump Pit	WC-8	537	537	
3503 & Off-Gas Drain	WC-9	337	337	
3508	WC-5 & WC-6	160	0	104
3525	W-12	1857	900	
3544 Feed	W-22	652	652	
7920-TRU	WC-20	1742	1753	
HFIR	HFIR	2996	3029	
3028	WC-2	91	0	
3504	WC-7	21	8	
30260	W-16	410	0	
3026C	W-17 & W-18	1745	202	967
3019	W-22	899	890	
3025	WC-3	19	18	
3074	Trucked	352	382	
7602-EGCR (b)	Trucked	315	500	
7500 (c)	Trucked	52	52	
2531-sumps,etc	W-22	1971	1971	
		26,418	19,558	5,153

(a) Isotopes area includes Bldgs. 3028E,3029,3030 3031,3032,3033,3033A,3038E, and 3047.

(b) EGCR will not be transporting any waste to the LLLW evaporator in 1989.

(c) The LLLW volume from the 7500 area in 1988 was a one-time transfer of 620 gallons.

(d) These volumes exclude those already taken into consideration by the generator and/or Waste Operations. Calculations based on time series analysis results.

(e) awaiting more information from generator data, has been utilized to construct a mass balance of the LLLW system. This mass balance will be presented in Section 6.

2.2 LLLW COLLECTION TANK DATA

Daily LLLW collection volume data obtained from the weekly summary reports distributed by the Liquid and Gaseous Waste Operations Group in the Environmental and Health Protection Division, are included in the data base. These reports were first distributed in 1986, and all reports have been entered into the data base. The levels in the 22 active LLLW collection tanks are measured daily and the daily collection volumes are calculated from differences in level changes. Other information added to the data base concerning the collection tanks includes capacities, locations, rainwater inleakage rates, and source buildings that feed each tank. Sample analyses that have been performed on any of the collection tank wastes are kept in the data base as well.

2.3 EVAPORATOR/EVAPORATION DATA

General information concerning the evaporator and evaporator service tanks has been recorded in the data base. During operation of the evaporator system, liquid volumes transferred into and out of the evaporators are recorded by the operators. Several thousand gallons of dilute LLLW may be transferred into the evaporator at distinct time intervals before concentrate is removed. This information was analyzed and put into the computer, and is referred to as "evaporator campaign" data. A campaign begins with the first transfer of LLLW into the evaporator and ends with the first removal of concentrate. Data beginning in 1986 have been summarized in this way and recorded in the data base. This data was analyzed to determine the major generators of LLLW concentrate. The data also allows volume reduction factors to be calculated.

2.4 LLLW CONCENTRATE DATA

Concentrate removed from the evaporator is pumped to one of several storage tanks (W-21, W-23, C-1, C-2, or the Melton Valley Storage Tanks-MVSTs). Routinely generated PWTP concentrate is stored in tank W-21. The volumes of concentrate generated are kept in the data base, as well as the monthly readings of the liquid levels in the storage tanks. (There is a slight discrepancy between the recorded concentrate volumes generated and the storage tank volume increases due to the accuracy of the instrumentation, therefore both data are recorded). Several sample campaigns have been performed on the contents of the MVSTs. The analytical results from these sampling campaigns are recorded in the data base also. When in-tank evaporation of the MVSTs' contents begins, this information will also be put into the data base.

2.5 DEVELOPMENT PLANS FOR THE LLLW SYSTEM DATA BASE

As mentioned in the introduction, the data base will be accessed by a user friendly, menu-driven software program. A general outline of the menus used to retrieve the data is shown in Fig. 2.1. The completed work to date includes the programming for the first three selections from the main menu, that is, retrieval of the generator information, the collection tank information, and the evaporator campaign information. Work is continuing on the concentrated LLLW information and systems analyses retrieval systems. User documentation will be prepared, and training classes held to introduce users to the capabilities of the data base as part of the FY-90 milestone.

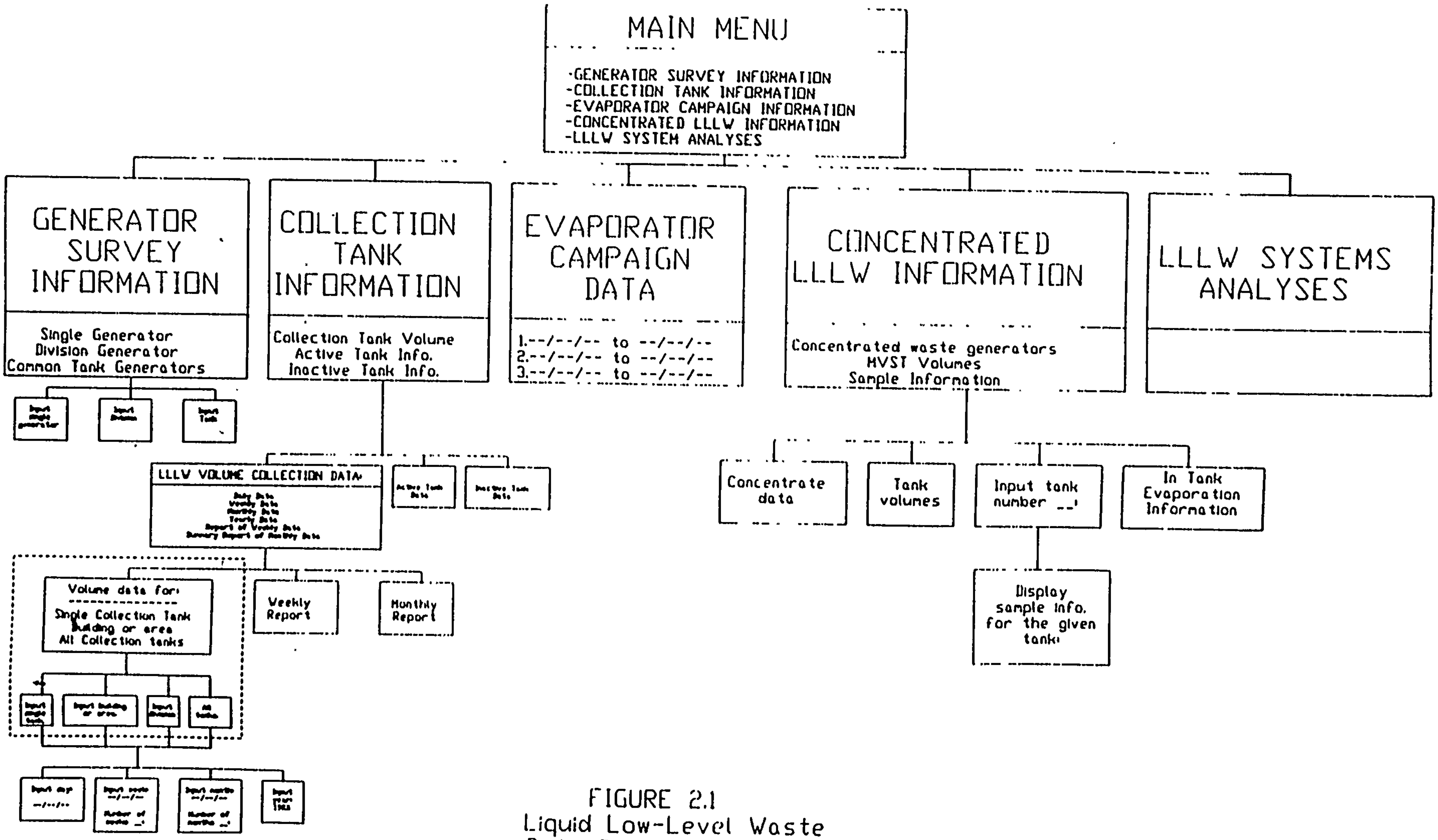

FIGURE 2.1
Liquid Low-Level Waste
Data Base Organization

3. DESCRIPTION OF THE LIQUID LOW-LEVEL WASTE SYSTEM

Radioactively contaminated liquid wastes at ORNL are generated by various activities including research activities performed within many Divisions, hot cell decontamination activities in the isotope development areas of the Chemical Technology Division, and reactor operations within the Research Reactors Division. Other significant sources of LLLW include the Laboratory's waste treatment facilities. These facilities include the Process Waste Treatment Plant (PWTP- Building 3544) and the Central Off-gas System (Building 3039). Another major LLLW generator is expected to be the remedial actions cleanup of inactive tanks and facilities during the next 10 years. Further discussion of the LLLW and the generators follows in Sect. 4.

Figure 3.1 shows a schematic of the LLLW system. LLLW generated by various activities at the Laboratory are discharged by way of "hot" drains located in laboratory sinks, hoods, floors, and hot cells, or the liquid is collected and trucked. Waste that is collected in "hot" drains flows by gravity through singly- or doubly-contained pipes to underground, stainless steel collection tanks where the waste is neutralized, if necessary. The piping and tanks are known as the Collection and Transfer System (CAT). The waste accumulated in the collection tanks is transferred via underground piping to the LLLW Evaporator Facility (Building 2531) where it is concentrated in one of the two evaporator units that reduce the volume of LLLW by a factor of about 20. From there the concentrated waste is transferred to one of several storage tanks, and the condensate collected from the evaporator operation is transferred to the PWTP for further treatment.

3.1 LLLW COLLECTION SYSTEM

ORNL's LLLW collection and transfer system is divided into two branches, the Melton Valley Branch and the Bethel Valley Branch. Currently, there are 22 active collection tanks, 4 of which serve the Melton Valley area and the remaining 18 tanks serve the Bethel Valley area. There are 33 inactive collection and storage tanks. The locations of the active collection tanks are shown in Fig. 3.2. Also shown in the figure is the inactive tank W-1A, which is periodically pumped to the evaporator system because of rainwater inleakage. The collection tanks and their capacities are given in Table 3.1. The CAT system was designed and constructed in the 1950s. Most of the floor drains, collection tanks, and transfer lines in the system are singly-contained. The system was designed to work approximately 20 years; however, most of the system is older than this. Current regulations and orders pertaining to this ·em require doubly-contained piping and tanks, leak detection capability, and extensive documentation of waste generation. In order to

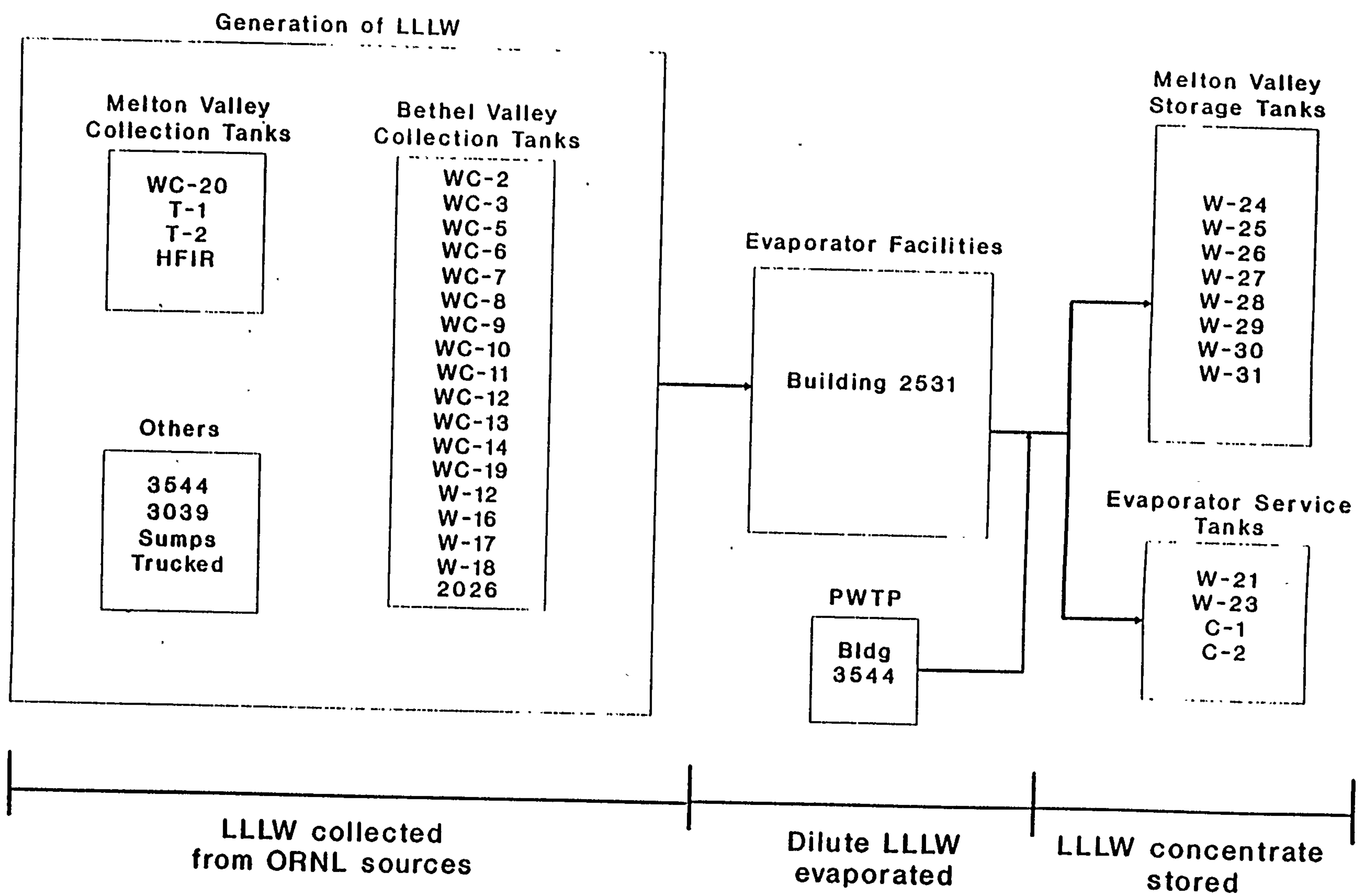

Fig. 3.1. LLLW system description.

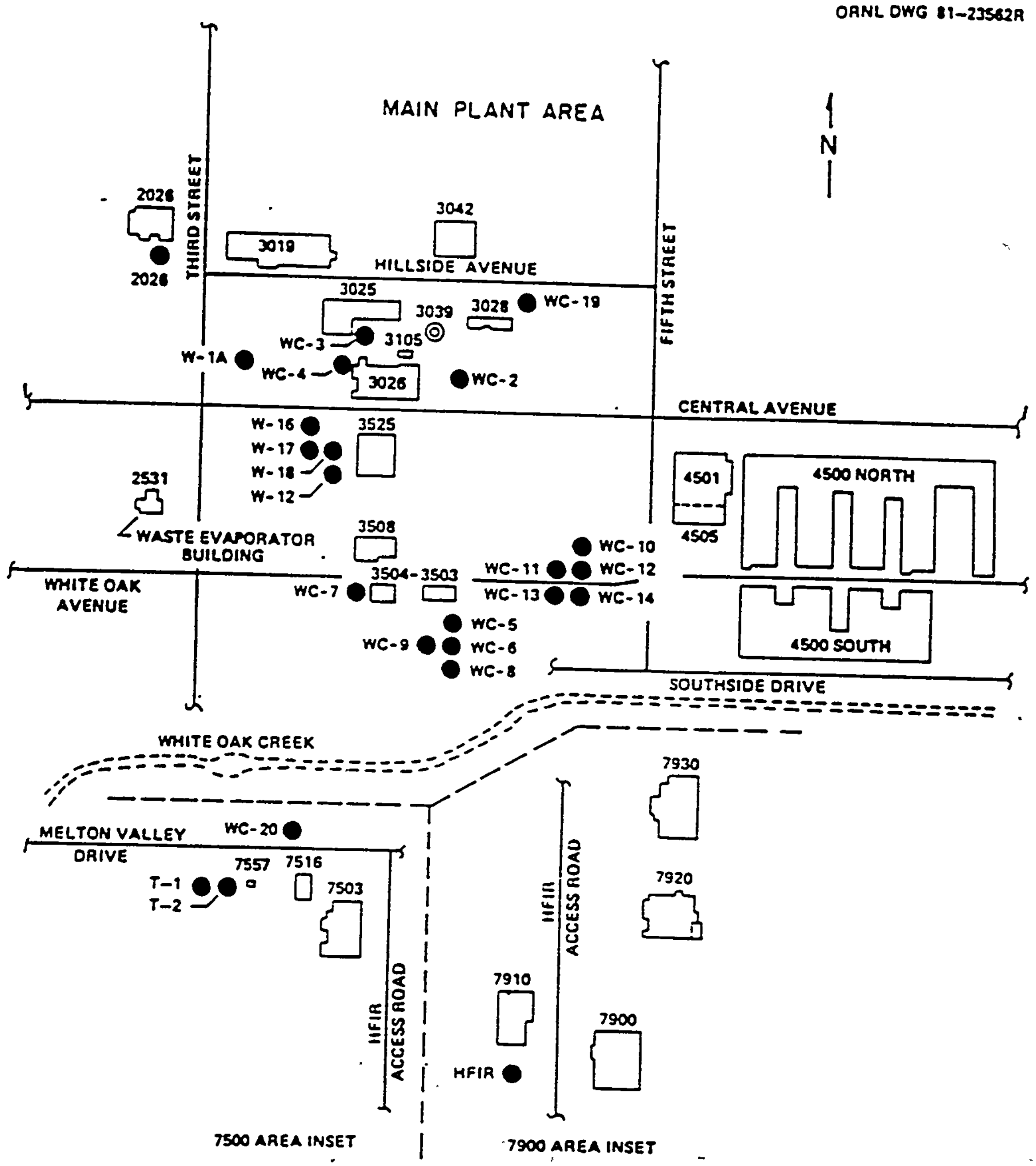

Fig. 3.2. Location of active collection tanks.

Table 3.1. Collection tanks capacities and source buildings

Tank	Tank capacity (gallons)	Operating capacity (gallons)	Source building(s)
	Bethel Valley Collection Tanks		
2026[a]	500	350	2026
W-1A[b,c]	4,000	3,000	(abandoned)
WC-2[a]	1,000	700	3028 3038
WC-3[a]	1,000	700	3025E 3025M 3098
WC-4[a,c]	1,700	1,200	(abandoned)
WC-5[a]	1,000	750	3508
WC-6[a]	500	350	3508
WC-7[a]	1,100	750	3504
WC-8[a]	1,000	750	Pump pit
WC-9[a]	2,140	1,550	3503 Off-gas
WC-10[b]	2,300	1,650	3028 3029 3030 3031 3032 3033A 3047 3092 3093 3110
WC-11[b]	4,600	2,900	4500N 4505 4507 4507
WC-12[a]	1,000	700	4505
WC-13[a]	1,000	700	4500N 4500S 4501 4508

Table 3.1. (continued)

Tank	Tank capacity (gallons)	Operating capacity (gallons)	Source building(s)
WC-14[a]	1,000	700	4501
WC-19[b]	2,100	1,500	3001 3002 3003 3004 3005 3008 3042 3109 3119
W-12[a]	700	400	3525E
W-16[a]	1,000	700	3026D
W-17[a]	1,000	700	3026C
W-18[a]	1,000	700	3026C
	Melton Valley Collection Tanks		
WC-20	10,000	7,000	7920 7930
T-1	15,000	10,500	7500 7503 7900 7911 7913 7920 7930
T-2	15,000	10,500	7500 7503 7900 7911 7913 7920 7930
HFIR	13,000	9,100	7900 7911 7913

[a]Vertical tank.
[b]Horizontal tank.
[c]Inactive tank.

comply with the regulations, the system is being upgraded and/or replaced. The work is underway, and is expected to take approximately 6 years to complete.

Each collection tank is equipped with a sampling device, liquid-level instrumentation, and a filtered vent to the atmosphere or to the off-gas system of the facility that it serves. Underground collection tanks in the Bethel Valley area have "dry wells," which are concrete pads with sumps located at the low point and wells extending to the surface of the ground where groundwater is sampled to identify tank leakage. A typical tank design is shown in Fig. 3.3. A network of 0.05- and 0.08-m (2- and 3-in.) stainless steel underground pipelines connect the collection tanks to one of two 0.15-m (6-in.) doubly-contained, stainless steel collection headers that directs the flow through doubly-contained piping to the evaporator feed tank, W-22. Several source buildings feed waste directly to the collection header at valve box #2. Waste is transferred by centrifugal pumps or steam jets.

3.2 LLLW EVAPORATOR FACILITY

Liquid low-level waste solutions that accumulate in the collection tanks are periodically transferred to the evaporator service tank W-22, and then fed to evaporators A2 and/or 2A2 in which the processing of the radioactive waste solution is accomplished. The two evaporators are operated in a semi- continuous manner. Dilute LLLW is automatically transferred by steam jet from the evaporator feed tank, W-22, to the evaporator as necessary to maintain an operating level in the evaporator where the waste is concentrated to a target specific gravity of approximately 1.25. The evaporator condensate, which may contain traces of radionuclides, is directed to the PWTP.

When the evaporator bottoms or concentrated waste reaches a specific gravity between 1.25 and 1.5, or when there is no feed left to process, the evaporator is shutdown, the contents cooled, and the "concentrate" jetted to one of the eleven storage tanks which are discussed in more detail in Sect. 3.4.

The transfer of the concentrate from the evaporator facility to the storage tanks is done through a doubly-contained stainless steel line that is cathodically protected and buried in a bed of specially prepared clay. The transfer route to the Melton Valley area (where the storage tanks are located) is shown in Fig. 3.4.

3.3 LLLW EVAPORATOR FACILITY COMPLEX

The Radioactive Waste Evaporator Facility (Bldg. 2531) shown in the plan view of Fig. 3.5, includes the following major areas:

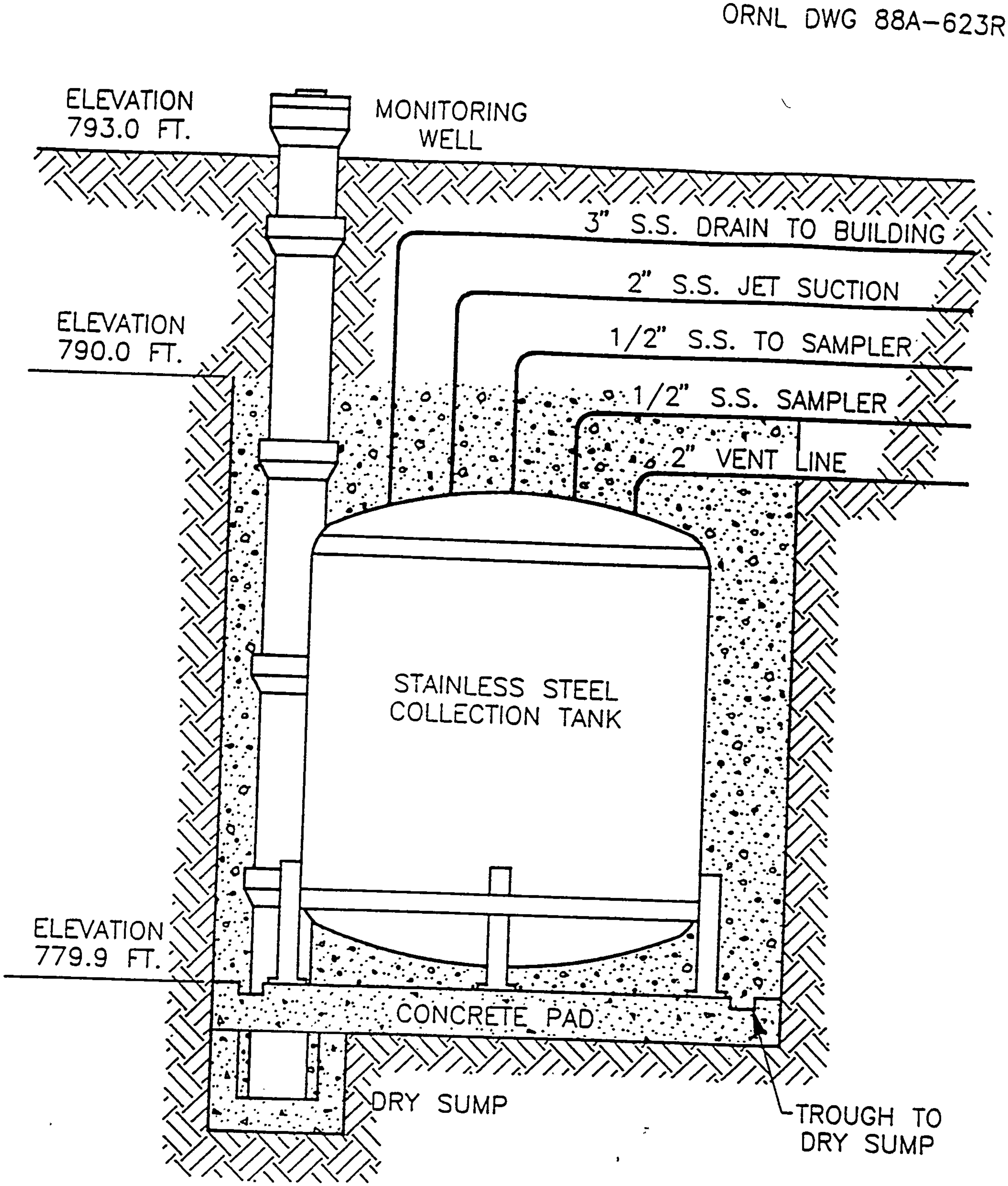

Fig. 3.3 Typical vertical collection tank.

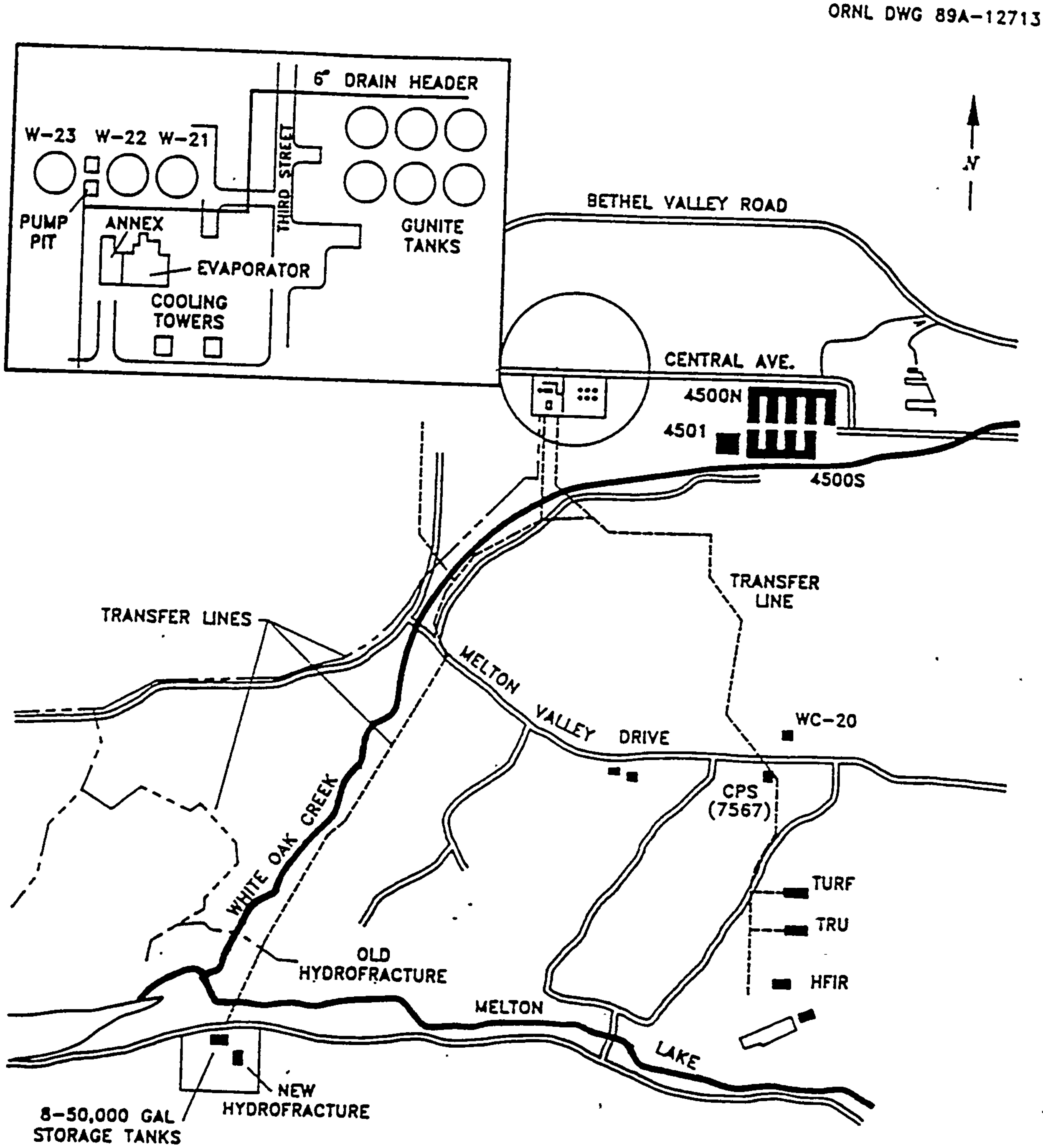

Fig. 3.4. Transfer line to the Melton Valley Hydrofracture site.

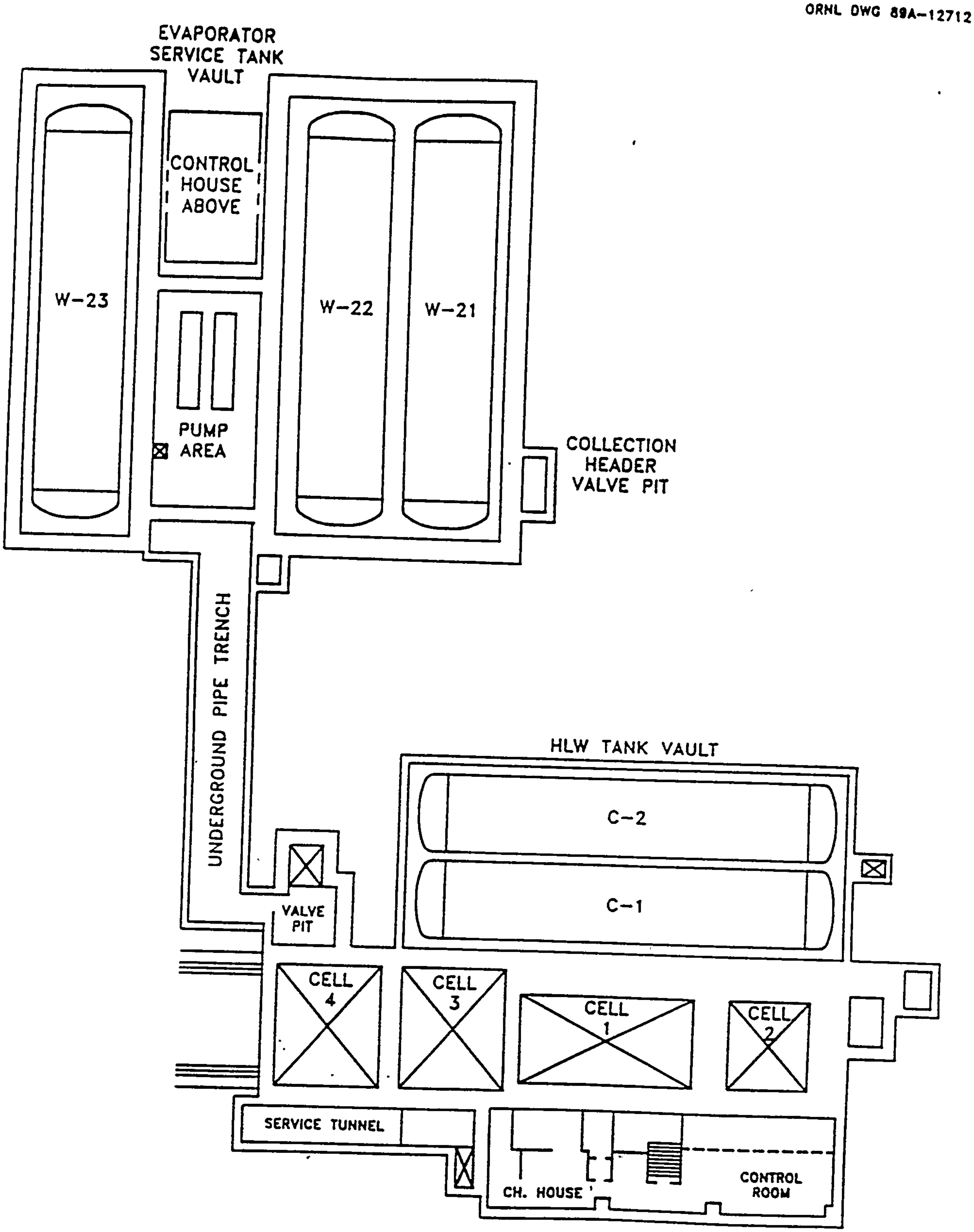

Fig. 3.5. Plan view of the Evaporator Facility Complex, Bldg. 2531.

(a) Evaporator service tank vault containing the evaporator feed tank W-22, the converted evaporator feed tank W-21 (now a storage tank for concentrated liquid waste generated by the PWTP), the concentrate storage tank W-23, and associated pumps, pipes, and controls.

(b) Underground pipe trench, for the transfer of liquid waste from the feed tank to the evaporator.

(c) The HLW tank vault containing tanks C-1 and C-2 which are now storage tanks for concentrated waste from the evaporator.

(d) Cells 1 through 4 in Building 2531 contain the evaporators and associated equipment. Cell 1 contains evaporator A-2 and its feed tank, A-1. Cell 2 contains the auxiliary process equipment associated with evaporator A-2, which includes the condenser, vapor filter, condensate catch tank, off-gas scrubber, emergency condenser and scrub liquor tank. Cell 4 holds evaporator 2A-2, and Cell 3 contains the condensate filter, evaporator condenser, condensate surge tank, off-gas scrubber, and the scrub liquor tank for evaporator 2A-2. Also in the building are the control room and service tunnel.

The evaporator service tanks W-21 and W-22 are enclosed in underground stainless steel-lined concrete vaults.

3.4 LLLW CONCENTRATE STORAGE TANKS

ORNL has twelve 50,000 gallon capacity tanks for the storage of LLLW concentrate. Eight of these tanks, known as the Melton Valley Storage Tanks (MVSTs), are located on the new Hydrofracture site in an underground concrete, stainless steel-lined vault. The other 4 storage tanks, located near the evaporator facility, are C-1, C-2, W-21, and W-23. Both C-1 and C-2 were originally built to contain high-level waste, but since high-level waste is not currently generated at ORNL, they were repiped to receive LLLW concentrate. W-21, originally a feed tank for the LLLW evaporator, was converted to a tank for storage of concentrate produced by the PWTP in an effort to decouple the PWTP and LLLW operations. Currently, tank W-22 serves as the sole evaporator feed tank. Tank W-23 receives concentrate directly from the evaporator. It is normally used as a collection point for LLLW concentrate before it is transferred to the MVSTs for storage.

4. LLLW SOURCES AND GENERATION

As mentioned briefly in the Sect. 3, several facilities contribute to the generation of LLLW. The radioactive liquid waste generated at the Laboratory can be broken down into several types of waste: (1) those wastes which result from air and water treatment facility operations, (2) those wastes which result from decontamination of hot cells and various areas, and (3) research and development activities. Of these types of LLLW, air and water treatment facility operations have accounted for approximately 34% of the LLLW wastes generated since 1986. Decontamination activities have generated about 45% of the waste, and other activities, including R&D activities and rainwater infiltration, account for the other 21%. Contributions of rainfall to the LLLW system are discussed further in Section 4.2.

Table 4.1 gives a list of those divisions which produce LLLW and corresponding approximate percentages of LLLW generated over the last 3 years. As seen in the table, the Chemical Technology Division is the largest producer of LLLW, accounting for almost half of the LLLW generated. Most of these wastes are generated by decontamination activities involving isotope production. The second largest divisional generator, at 27%, is the Environmental and Health Protection Division. These wastes consist mainly of air and water treatment residual liquids; those from the PWTP and the Central Off-Gas (COG) stack. Research Reactors Division has produced about 23% of the LLLW generated since 1986.

4.1 LLLW GENERATORS

A general description of the LLLW System was given in Sect. 3. More detailed information about LLLW generation rates and the activities of specific generators will be reviewed in this section.

4.1.1 <u>LLLW Generation Rates</u>

As mentioned in Sect. 2, the ORNL LLLW system is used to collect, neutralize, concentrate, and store radioactive waste solutions. Annual summaries of the monthly LLLW collected from specific generators as reported by the Liquid and Gaseous Waste Operations Group of the E&HP Division are contained in Tables 4.2-4.6. Table 4.2 summarizes collections of LLLW over the period from January 1986 through June 1989, and Tables 4.3, 4.4, and 4.5 summarize monthly LLLW generation rates from 1986, 1987, and 1988 respectively. Table 4.6 summarizes monthly LLLW generation rates through June 1989. As the data in these tables demonstrate, relatively few generators are

Table 4.1. Divisions' contributions to LLLW

Division	Average 1986-1989 % of LLLW Generation
Analytical Chemistry	1
Chemistry	<1
Chemical Technology	47
Environmental & Health Protection	27
Environmental Sciences	<1
Health & Safety Research	<1
Metals and Ceramics	<1
Plant and Equipment	<1
Research Reactors	23

Table 4.2. Average monthly dilute LLLW generation (Jan. 1986-June 1989)

Generator	Monthly generation (gallons)	Percent of total
Isotopes[a]	5061	16
HFIR	3890	13
3039 stack area	3552	11
Reactors[b]	3210	10
Fission Products Development Lab	3120	10
High Radiation Level Examination Lab	2615	8
4500 complex	2609	8
Tank W1-A[c]	2319	8
TRU	1370	4
Bldg. 3019	1061	4
PWTP spent acid	999	3
Tank WC-8 pump pit	545	2
All others	835	3
Total:	31,186	

[a]Isotopes includes all collections from Isotopes Area collection tank, Building 3026C collection tank, and Bldg. 3026D collection tank.

[b]Reactors included are the ORR, the BSR, and the Graphite Reactor.

[c]Tank W1-A is abandoned and the collections are considered to be primarily rain water.

Table 4.3. Average monthly dilute LLLW generation for 1986

Generator	Monthly generation (gallons)	Percent of total
Isotopes[a]	7466	17
Reactors[b]	5455	13
HFIR	5370	12
4500 complex	5110	12
Fission Products Development Lab	4629	11
High Radiation Level Examination Lab	3770	9
3039 stack area	3480	8
PWTP spent acid	2130	5
Tank W1-A[c]	1720	4
REDC	1608	4
Building 3019	1151	3
Tank WC-8 pump pit	534	1
All others	703	2
Total:	43,126	

[a]Isotopes includes all collections from Isotopes Area collection tank, Building 3026C collection tank, and Bldg. 3026D collection tank.

[b]Reactors included are the ORR, the BSR, and the Graphite Reactor.

[c]Tank W1-A is abandoned and the collections are considered to be primarily rain water.

Table 4.4. Average monthly dilute LLLW generation for 1987

Generator	Monthly generation (gallons)	Percent of total
Isotopes[a]	3779	14
Reactors[b]	3601	13
3039 stack area	3539	13
Fission Products Development Lab	3362	12
HFIR	2620	10
4500 complex	2419	9
Building 3019	2172	8
High Radiation Level Examination Lab	1830	7
REDC	1188	4
Tank W1-A[c]	1004	4
PWTP spent acid	592	2
3503 and off-gas drain	457	2
Tank WC-8 pump pit	293	1
All others	532	1
Total:	25,216	

[a]Isotopes includes all collections from Isotopes Area collection tank, Building 3026C collection tank, and Bldg. 3026D collection tank.

[b]Reactors included are the ORR, the BSR, and the Graphite Reactor.

[c]Tank W1-A is abandoned and the collections are considered to be primarily rain water.

Table 4.5. Average monthly dilute LLLW generation for 1988

Generator	Monthly generation (gallons)	Percent of total
Isotopes[a]	3766	16
3039 stack area	3275	14
Fission Products Development Lab	3150	13
HFIR	2996	12
High Radiation Level Examination Lab	1857	8
REDC	1742	7
4500 complex	1605	7
Reactors[b]	1378	6
Tank W1-A[c]	1161	5
Building 3019	899	4
PWTP spent acid	652	3
Tank WC-8 pump pit	537	2
All others	1064	3
Total:	24,082	

[a]Isotopes includes all collections from Isotopes Area collection tank, Building 3026C collection tank, and Bldg. 3026D collection tank.

[b]Reactors included are the ORR, the BSR, and the Graphite Reactor.

[c]Tank W1-A is abandoned and the collections are considered to be primarily rain water.

Table 4.6. Average monthly dilute LLLW generation (Jan.-June 1989)

Generator	Monthly generation (gallons)	Percent of total
Tank W1-A[c]	5394	18
Isotopes[a]	5232	17
HFIR	4572	15
3039 Stack Area	3914	13
High Radiation Level Examination Lab	3004	10
Reactors	2405	8
Fission Products Development Lab	1337	4
4500 complex	1302	4
Transuranium Processing Plant (TRU)	941	3
Tank WC-8 pump pit	816	3
PWTP Spent Acid	620	2
Building 3019	23	<1
All others	1064	3
Total:	30,624	

[a]Isotopes includes all collections from Isotopes Area collection tank, Building 3026C collection tank, and Bldg. 3026D collection tank.

[b]Reactors included are the ORR, the BSR, and the Graphite Reactor.

[c]Tank W1-A is abandoned and the collections are considered to be primarily rain water.

responsible for the generation of most of the LLLW collected at ORNL since 1986. The primary generators are the Isotopes Area (16%), the High-Flux Isotope Reactor (HFIR) (13%), the 3039 Stack Area (11%), the Oak Ridge Research Reactor (ORR) and the Bulk Shielding Reactor (BSR) (10%), the Fission Products Development Laboratory (FPDL) (10%), The High Radiation Level Examination Laboratory (8%), the 4500 Complex (8%), the Radiochemical Engineering Development Center (REDC) (4%), Building 3019 (4%), and the Process Waste Treatment Plant spent acid stream (3%). General descriptions of the activities of specific large LLLW generators follow in the next few sections. Two important LLLW generators will not be described in any detail in this section; they are Building 3019, which is expected to be only a minor LLLW generator in the future, and tank W1-A which is an inactive tank and only collects rainwater.

4.1.2 Isotopes Area

The isotopes facilities at ORNL are used primarily for producing and distributing various radionuclides. A very wide range of radioisotopes are handled, and activities include tritium processing, krypton-85 separation, short lived fission products processing, cesium-137 and strontium-90 source fabrication, cobalt-60 storage and irradiation, technicium-99 processing, and some transuranic isotope processing.

As summarized in Table 4.2, LLLW collections from the Isotopes Area have accounted for 16% (5061 gal/month) of the total LLLW collections since 1986. LLLW generation from the Isotopes Area decreased dramatically from 1986 (7466 gal/month) to 1987 (3779 gal/month) and remained approximately 3800 gal/month in 1988. However, through the first half of 1989 LLLW generation has increased to 5232 gal/month due to above average rainfall inleakage into tanks W-17 and W-18. Further discussion of rainfall influence into Isotopes Area collection tanks will follow in Section 4.2. Collection tanks in the Isotopes Area are WC-10, W-16, W-17, and W-18.

While the Isotopes Area is primarily a production facility, very little LLLW is generated as a direct result of processing activities. Most of the waste production is a result of routine and non-routine hot cell decontamination. The primary nuclides expected to be in the waste streams generated from these facilities are cesium-137 and strontium-90. However, smaller quantities of many other nuclides can also be expected to be present in the waste stream. A list of these other nuclides and the estimated quantity of each is given in Table 4.7. Also presented in Table 4.7 is a list of other components in the Isotopes Area waste stream and their respective estimated quantities.

Table 4.7. Annual LLLW stream components for the isotopes area

Nuclide	Annual quantity (Ci)	Other stream component	Annual quantity (kg)[a]
Ag-110m	0.8	AHIB (organic acid)	1
Am-241	Trace	Ammonium hydroxide	2
AM-243	Trace	Citric acid	11
Cf-252	Trace	Hydrochloric acid	2
Cm-244	Trace	Methyl isobutyl ketone	1
Co-56	Trace	Nitric acid	104
Co-60	3	Oxalic acid	33
Cs-137	30	Potassium hydroxide	2
Eu-152	Trace	Potassium permanganate	27
Eu-154	Trace	Sodium hydroxide	4
Fe-55	Trace	Sulfurous acid	90
Fe-59	Trace	Detergents	210
Gd-153	Trace		
H-3	1.2E-4		
I-125	1.2E-3		
I-129	3		
Ir-192	Trace		
Mn-54	Trace		
Ni-63	Trace		
Pm-147	3		
Pu-238	Trace		
Pu-239	Trace		
Sr-90	30		
Tc-99	3		
U-234	Trace		
U-235	Trace		
W-188	1.2E-3		

[a]For purposes of this report "other stream component" quantities considered to be 1 kg when estimated quantities are less than 1 kg. All others are rounded to the nearest kg.

4.1.3 High Flux Isotopes Reactor

LLLW collected from the HFIR is generated primarily from the following sources: (1) regeneration and backwashing of primary and pool demineralization systems, (2) waste from sampling, (3) head tank overflow, (4) gaseous waste filter pit, (5) 7911 stack drainage, and (6) the off-gas condensate collection pit. An analysis of the primary demineralizer LLLW stream is summarized by Pretez in ORNL TM-10218 entitled "Characterization of Low-Level Wastes at the Oak Ridge National Laboratory." The LLLW generation rate in 1986 was approximately 5370 gal/month. With the HFIR shut down in 1987 and 1988 the LLLW generation rate fell to approximately 2800 gal/month. However, the HFIR restart in 1989 has increased LLLW generation to approximately 4600 gal/month in 1989.

The most significant LLLW generation source is the regeneration and backwashing of the primary and pool demineralization systems. These regeneration solutions account for approximately 20,000 gallons of dilute LLLW annually and also represent the primary source of cobalt-60 at ORNL. The regenerations contribute approximately 2,320 gal/yr of 5% nitric acid and 5325 gal/yr of 5% sodium hydroxide to the LLLW stream as well.

Liquid low-level waste generated in the HFIR area of Melton Valley is collected in the HFIR tank and subsequently sent to either collection tank T-1 or T-2, also in Melton Valley. From here the waste is transferred to tank W-22 in Bethel Valley. As previously mentioned, the HFIR LLLW stream contains ~~is~~ the primary source of Co-60 at ORNL with an estimated 5 Ci/yr. In addition to Co-60, several other nuclides including Cs-137, Cr-51, Eu-152, Eu-154, Mn-54, and Ta-182 may also be present in trace amounts.

4.1.4 3039 Stack Area

Process off-gas streams generated within processes or R&D equipment are vented to the central off-gas collection system (3039 stack) for the removal of radioactive iodine. The off-gases potentially contain other radioactive species, flammable vapors, and toxic vapors. After collection, the gases are scrubbed with a 0.5% caustic (NaOH) solution, passed through a HEPA filter, and are then discharged. The scrubbing operation produces a spent caustic solution that is slightly contaminated. This caustic solution is then transferred directly to service tank W-22 in the LLLW system for subsequent treatment. The 3039 Stack Area produces approximately 3600 gallons per month of dilute LLLW which accounts for approximately 11% of the total volume of dilute LLLW collected since 1986.

Past sampling data show that the LLLW stream produced at the 3039 Stack area is quite dilute. Assuming that the LLLW evaporator concentrates the dilute LLLW to a specific gravity of 1.25 g/ml, this stream contributes less than 50 gallons per month to the LLLW concentrate stream.

4.1.5 Oak Ridge Reactor/Bulk Shielding Reactor/Graphite Reactor

The Oak Ridge Reactor (ORR) was shut down permanently in 1987 and will not be restarted. Current and future LLLW generated at the ORR is the result of decontamination and decommissioning activities, as well as regeneration of the demineralizer columns. Similarly, ongoing maintenance and decommissioning activities require the regeneration of demineralizers at the Graphite Reactor. These regenerations are the only source of LLLW at this facility.

The Bulk Shielding Reactor (BSR), on the other hand, is expected to continue operation. Sources of LLLW from the BSR are cooling water and ion exchange column spent regeneration solutions.

The monthly LLLW generation from these facilities has averaged approximately 3200 gal/month since 1986, falling from a level of 5500 gal/month in 1986 to a level of approximately 1400 gal/month in 1988. Much of the decrease between 1986 and 1988 was due to the shutdown of the Oak Ridge Reactor and relatively light rainfall in 1987 and 1988. With increased rainfall during the first half of 1989, generation rates have increased to 2400 gal/month. More discussion pertaining to the influence of rainfall into the collection tank (WC-19) for these facilities will follow in Section 4.2.

The LLLW stream from each of these facilities can be described as a stream primarily resulting from the regeneration of demineralization systems. As such, each of the individual contributing streams releases weak acids and bases used in the regenerations to the LLLW system. It is estimated that a total of 460 gallons of 5% nitric acid, 110 gallons of 5% sulfuric acid, and 575 gallons of 5% sodium hydroxide are expended annually for regeneration purposes in these facilities. The total waste stream from these facilities is also estimated to contain as much as 3 Ci/yr Ru-106 and trace amounts of such nuclides as Co-60, Cs-137, Mn-54, Ra-226, and Sr-90.

4.1.6 Fission Products Development Laboratory

The Fission Products Development Laboratory (Bldg. 3517) processes large quantities of cesium-137 (Approximately 350,000 Ci/year) and strontium-90 (approximately 500,000 Ci/year). Other materials that are occasionally processed at Bldg. 3517 are cobalt-60 and iridium-192.

Materials that have been handled in the past include cerium-144 and promethium-147.

Building 3517 is the primary source of both cesium and strontium in the LLLW system. Estimated losses of each material are on the order of 5000-15,000 curies/year. The building activities that produce LLLW are not directly related to isotope processing, but are derived primarily from routine decontamination of the hot cells used in cesium and strontium purification. In addition to the nuclides released to the LLLW system, this routine decontamination also results in the addition of 16M nitric acid (500 gal/yr), oxalic acid (500 lbs/yr), 50% sodium hydroxide (300 lbs/yr), Turco Decon 4502 (500 lbs/yr), and various detergents to the LLLW system.

The LLLW production since 1986 has averaged approximately 3100 gal/month, but the level decreased substantially during the time period from 1986 to 1989. In fact, the LLLW production rate in 1986 was approximately 4600 gal/month, and by 1988 that production rate had fallen to 3150 gal/month. Shutdown of the facility in early 1989 has resulted in even smaller volumes of LLLW (1337 gal/month) being sent to the LLLW system thus far in 1989. Recently, improvements have been made to the building's underground tank vault which has reduced ground water inleakage, and consequently, the LLLW generation rates are expected to decrease even further. Waste from Bldg. 3517 is jetted directly to W-22.

4.1.7 <u>High Radiation Level Examination Laboratory</u>

The High Radiation Level Examination Laboratory (Bldg. 3525) primarily serves as an area where irradiated metallurgical specimens can be examined. The area possesses both hot cells and storage wells for containment of radioactive materials. Currently, the facility is expected to handle a variety of radionuclides including cesium-137, and uranium, plutonium, and thorium isotopes. It is estimated that 50 Ci/yr of Cs-137 and trace quantities of the various uranium, plutonium, and thorium isotopes escape to the LLLW system via collection and transfer tank W-12. As is the case for other isotope areas, LLLW in this facility is mainly generated as a result of routine decontamination. In addition to the above mentioned isotopes, sulfurous acid (450 lbs/yr), 15M sodium hydroxide (5 gal/yr), 5M nitric acid (5 gal/yr), and detergents used in decontamination activities contribute to LLLW.

The average monthly LLLW generation rate since 1986 has been approximately 2600 gallons. The LLLW generation rate decreased from a 1986 generation rate of 3770 gal/month to a rate of 1850 gal/month in 1988. In 1989, the LLLW generation rate has increased as expected to 3000 gal/month due to non-routine hot cell revitalization/ decontamination activities.

4.1.8 <u>4500 Complex</u>

The 4500 complex (Bldgs. 4500N, 4500S, 4501, 4505, 4507, and 4508) is a multi-purpose research facility. There is a large variation in the radioactive materials that are handled in the complex, and small quantities of any radionuclide that is used at the laboratory could be disposed of from one of many active hot drains in the facility. There are approximately 89 active hot drains in the 4500 complex each draining to one of four collection tanks, WC-11, WC-12, WC-13, WC-14, in the area (Cal Pepper).

The 4500 complex has historically accounted for between 7 and 8% of all dilute LLLW collected at ORNL. Since 1986, the average LLLW generation rate has been approximately 2600 gal/month. As seen in Tables 4.3-4.6, however, the monthly LLLW generation rate has decreased from approximately 5110 gal/month in 1986 to only 1300 gal/month for the first six months of 1989.

As previously mentioned, small quantities of many radionuclides could reasonably be expected to be found in the 4500 Complex waste stream. A summary of these nuclides and their respective estimated quantities is given in Table 4.8. As to be expected with a multi-purpose research facility, the 4500 Complex also releases small amounts of common acids, bases, detergents, and other chemical agents used in various laboratory procedures involving radioisotope research to the LLLW system. A list of these other LLLW stream components is provided in Table 4.8 as well.

4.1.9 <u>Radiochemical Engineering Development Center (REDC)</u>

The REDC recovers a variety of radiochemicals produced by special irradiations of selected isotopes. The REDC has produced approximately 1400 gal/month of LLLW since 1986. The LLLW is primarily generated from disposal of spent off gas scrubber solutions. The scrubber solutions are typically of low activity. There are small volumes of waste generated as a direct result of isotope processing from operations conducted at the REDC. These wastes are sent to the LLLW system via CAT tank WC-20 and are a major contributor to the transuranic isotopes which are collected. Table 4.9 summarizes the radioactive and nonradioactive components that are released to the LLLW system from the REDC.

Table 4.8. Annual LLLW stream components for the 4500 complex

Nuclide	Annual quantity (Ci)	Other stream component	Annual quantity (kg)[a]
Am-241	Trace	Ammonium hydroxide	1
AM-243	Trace	Hydrochloric acid	1
C-14	Trace	Methanol	1
Co-58	Trace	Nitric acid	49.8
Co-60	1.1E-2	Sodium hydroxide	1
Cs-134	6.0E-2	Sulfuric acid	2
Cs-137	0.7	Detergents	4
Eu-152	Trace	Acetone	4
Eu-154	Trace	Hydrofluoric acid	1
Fe-59	Trace	Potassium dichromate	50
H-3	1.2E-4		
Mn-54	Trace		
Pu-238	Trace		
Pu-239	Trace		
Pu-242	Trace		
Ra-226	Trace		
Sr-85	Trace		
Sr-90	Trace		
Tc-95m	Trace		
Tc-99	Trace		
Th-232	2.2E-6		
U-233	Trace		
U-238	3.4E-5		

[a]For purposes of this report "other stream component" quantities considered to be 1 kg when estimated quantities are less than 1 kg. All others are rounded to the nearest kg.

Table 4.9. Annual LLLW stream components for the Radiochemical Engineering Development Complex

Nuclide	Annual quantity (Ci)	Other stream component	Annual quantity (kg)[a]
Am-241	1.7	Acidified butyrates	1
Am-242	Trace	Adogen-hydrochloric acid	24
Am-243	0.1	AMSCO (petroleum naphtha)	768
Cf-252	0.8	2,5-dibutylhydroquinone	1
Cm-244	78.2	Diisoprophylbenzene (DIPB)	24
Cm-246	0.2	2-ethylhexanol	48
MFP	42,000	HDEHP extractant	151
Mixed Pu	0.5	Hydrochloric acid	146
Other Cf	Trace	Lithium chloride	123
Other Cm	Trace	Lithium nitrate	1
		Mercury (II) nitrate	3
		Nitric acid	1
		Potassium carbonate	9686
		Potassium hydroxide	2089
		Sodium aluminate	115
		Sodium hydroxide	284
		Sodium thiosulfate	1

[a]For purposes of this report "other stream component" quantities considered to be 1 kg when estimated quantities are less than 1 kg. All others are rounded to the nearest kg.

4.1.10 Overall System Collection Rates

Table 4.10 summarizes the total LLLW collections from all generators in 1986, 1987, and 1988. As of 1988, the LLLW collections have declined by approximately 44% since 1986. With the exception of LLLW generations from the TRU facility and the 3039 stack area, all generators seem to have substantially decreased their LLLW generation rates. The reason for this decline is in part the result of waste reduction programs spurred by institution of a charge back plan started at ORNL in 1986. Other factors influencing the decline in LLLW generation could be relatively light rainfall since 1986, the shutdown in 1986 of the HFIR, decommissioning of the ORR, and improvements in the operation of the Process Waste Treatment Plant. One result that can be gleaned from study of the data in Table 4.10 is that projected LLLW collections in 1989 are about 14% greater than the actual collections in 1988. This increase in LLLW collections may be due to increased fugitive inleakage related to higher rainfall levels to date in 1989 (1.55 in./wk.) compared to that in 1988 (0.83 in./wk.); however, the absolute amount of the LLLW generation increase that can be attributed to increased rainfall in 1989 is uncertain. Rainfall infiltration into the LLLW CAT system will be covered in more detail in Sect. 4.2.

4.2 RAINFALL INLEAKAGE INTO THE LLLW SYSTEM

Inleakage of rainfall into the LLLW system has been qualitatively recognized for some time, however, a quantitative estimate of the effects of rainfall on the volume of LLLW collected at ORNL has not been made. It was the objective of this work to derive a quantitative relationship between rainfall levels and LLLW collections and to determine which of the tanks in the LLLW system were effected by rainfall. The data necessary to perform this analysis, the weekly LLLW generation rates and weekly rainfall amounts, were obtained from the Liquid and Gaseous Waste Operations Group of the Environmental and Health Protection Division and from the Plant and Equipment Division, respectively.

A plot of LLLW collections as a function of rainfall is shown in Figure 4.1. It is obvious from Figure 4.1 that there is a high degree of scatter to the data. However, if the rainfall data is plotted in a time ordered plot with LLLW collections as in Figure 4.2, there appears to be a relationship between weekly rainfall and weekly LLLW collection rates.. Therefore, it was determined that a time series analysis was an appropriate approach to determine which tanks were, in fact, collecting rainwater and to derive a rough estimate of how much LLLW is created by a given amount of rain.

The time series analysis identified LLLW collections in the following tanks to be significantly influenced by rainfall: WC-19, W-1A, WC-11, WC- 12, Bldg. 3517 tanks, WC-8, WC-5, and WC-17 and WC-18. A very approximate estimate of LLLW collected

Table 4.10. Summary of annual LLLW production rates

Year	LLLW generation (gallons)	Change from previous year
1986	517,505	--
1987	328,638	-36.5%
1988	288,961	-12.0%
1989[a]	329,243	13.9%

[a]1989 LLLW generation rate is projected from actual LLLW collections as of August 27, 1989.

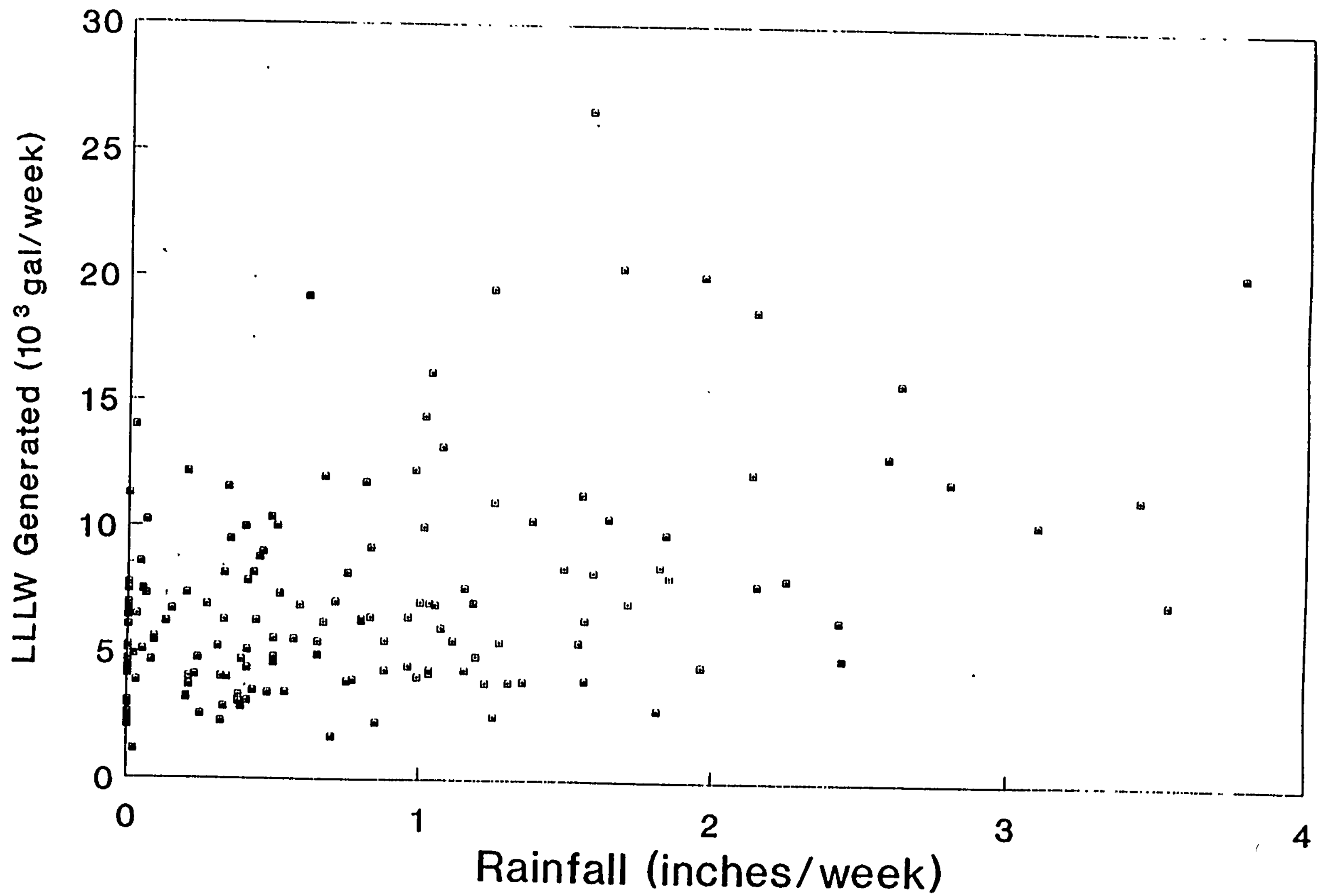

Figure 4.1. Liquid Low-Level Waste (LLLW) generation plotted as a function of rainfall for calendar years 1986-1988

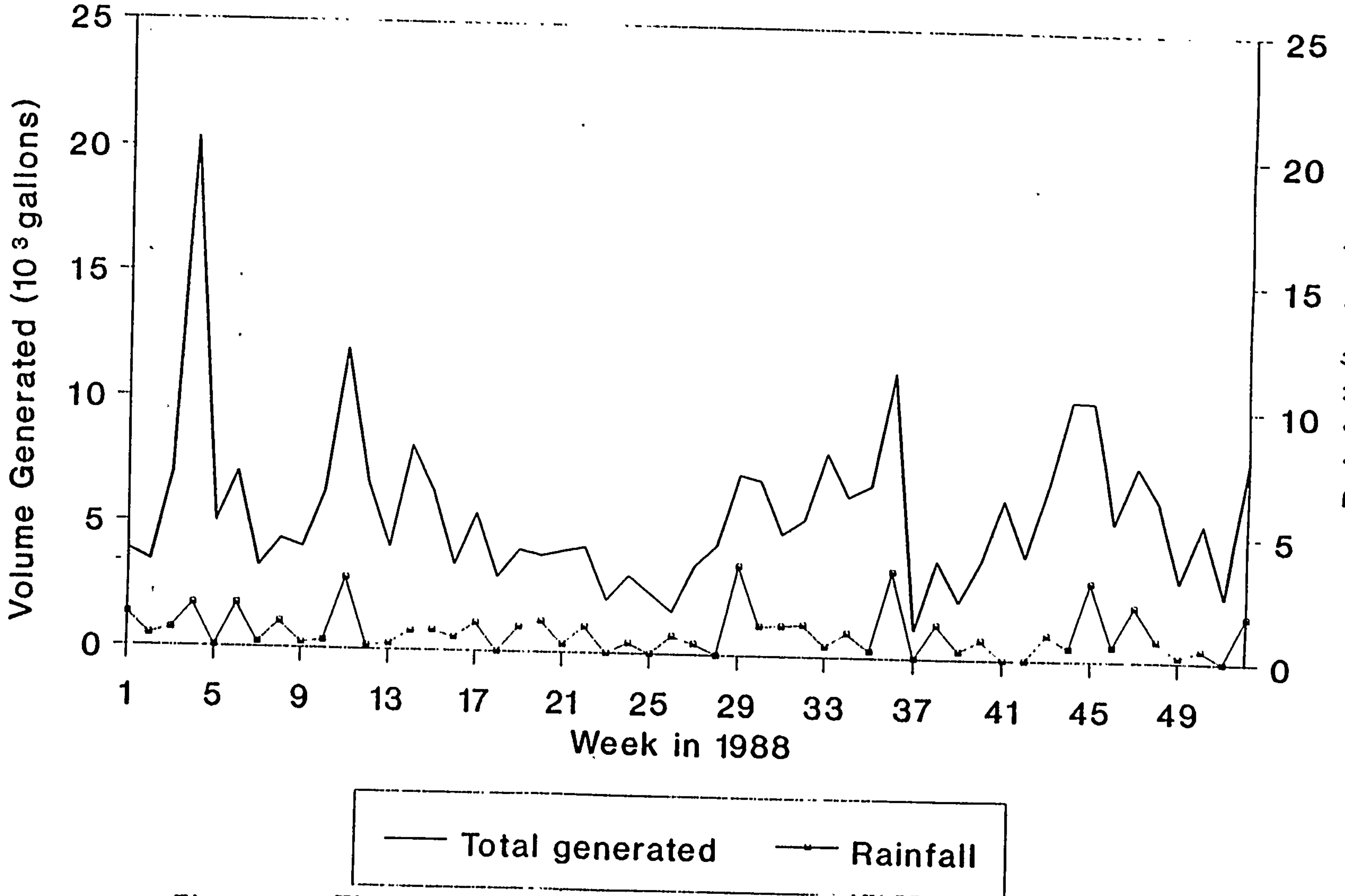

Figure 4.2. Time-ordered plot of Liquid Low-Level Waste (LLLW) generation as a function of rainfall for calendar year 1988

(in gallons) from each of these tanks per inch of rainfall is 223, 644, 93, 30, 138, 47, 28, and 260 respectively. These data imply that for each inch of rainfall there are approximately 1500 gallons of LLLW collected from the above tanks. It must be emphasized that all of these projections of LLLW generation as a function of rainfall are only approximations, and care must be taken when interpreting these results.

5. LLLW SYSTEM PERFORMANCE

Liquid Low-Level Waste is collected by the LLLW collection and transfer system, transferred to the evaporator feed tank (W-22), and fed semi-batchwise to one of the two LLLW evaporators as necessary to maintain adequate LLLW collection system capacity. The concentrate produced in each evaporator run or campaign is then transferred to one of several LLLW concentrate storage tanks in the evaporator complex and eventually transferred to the Melton Valley Storage Tanks. A description of the evaporation process was reviewed in Sect. 3.

While the LLLW evaporator is operated per a standardized procedure, the volume reduction factor (VRF) of each evaporator batch varies dramatically. The VRF is defined as the ratio of dilute LLLW fed to the evaporator to the concentrated LLLW produced from an evaporator campaign. The objectives of this study are (1) to determine which waste streams are the primary volume contributors to the LLLW concentrate (which will allow a prediction of the variability of the evaporator performance as a function of the LLLW collections from specific generators), (2) to explore the contributions of operational variability on the performance of the LLLW evaporator, and (3) to explore possible errors in the monitoring of dilute and concentrated LLLW inventories.

5.1 DATA SOURCES AND COLLECTION

The LLLW evaporator performance was analyzed using generator, evaporator feed, and concentrate production data specific to each evaporator batch or campaign. Data quantifying the specific LLLW feed sent to the evaporator complex (Bldg. 2531) for each LLLW evaporator campaign were gathered from the monthly LLLW Collection Tank Inventory and Transfers log sheets, Service Tank Balance Sheets, and a monthly summary of evaporator feeds and products collected by the Gaseous and Liquid Waste Operations Group in the E&HP Division. Data quantifying the concentrate produced from each LLLW evaporator campaign were extracted from the Service Tank Balance Sheets and the monthly summary of evaporator feeds and products. The LLLW collection volume information reported by the waste operations group is calculated from the daily changes in the level of each LLLW collection and transfer tank, evaporator service tank, and each Melton Valley Storage Tank. Although the accuracy of each of the tank level detectors cannot be quantified, it is generally understood that the accuracy of the level detectors is quite good and thus, errors in tracking the dilute and concentrated LLLW inventories cannot account for a large variability in the VRF. The following section will explore the possible effects of varying feed characteristics and operational variability on the VRF.

5.2 DATA ANALYSIS

The data in Table 5.1 summarize the dilute LLLW fed to the each of the LLLW evaporators from tank W-22, the concentrate production, and the VRF for each evaporator campaign from 1986 through 1988. The large variability in the VRF from different evaporator campaigns can be readily observed from Table 5.1. In fact, over the three year period from January 1986 to December 1988, the VRF of each evaporator batch has varied from a low of 5.3 to a high of 43.8. The reasons for the variability in evaporator performance are most likely two-fold: (1) the different characteristics of wastes routinely collected from individual generators vary in radionuclide and inorganic salt concentrations causing varying degrees of volume reduction efficiencies for specific waste streams and (2) variability in the operation of the LLLW evaporator.

5.2.1 Relationship Between VRF and LLLW Collections from Specific Generators

A Stepwise Regression Program of SAS was used to analyze the evaporator campaign data. The purpose of the analysis was to determine which generators, if any, were primarily responsible for LLLW concentrate production. A linear model which relates LLLW generation from specific generators to LLLW concentrate production is:

$$\text{SUM}\,(x(i)*a(i)) = 1.0/\text{VRF}$$

where x(i) is the volume fraction of the waste or rainfall collected from each LLLW generator for a given evaporator campaign and a(i) is a constant which represents the amount of concentrate produced from the volume of dilute LLLW collected from each generator or unit of rainfall during the campaign.

The regression analysis provided the following model:

$$1.0/\text{VRF} = \text{VF3544}*1.87 + \text{VF3517}*0.14$$
$$\text{R-squared} = 0.77$$

where VF3544 is the volume fraction of the Process Waste Treatment Plant ion exchange eluate sent to the LLLW system for evaporation and VF3517 is the volume fraction of waste collected from Fission Products Development Laboratory present in the dilute LLLW fed to the evaporator in a given evaporator campaign respectively.

The model demonstrates that of the many generators listed in Table 4.2 only the LLLW collected from two areas, the Process Waste Treatment Plant and the Fission Products Development Laboratory, contributes significantly (at a 90% confidence limit) to

Table 5.1. LLLW evaporator data, 1986-present.

Evaporator campaign dates	LLLW sent to evaporators (gal)		Concentrated LLLW generated (gal)		
	2A2	A1	2A2	A2	VRF
1986					
02/25 - 05/19	37,549	60,438	1183	5012	15.8
05/19 - 08/14	76,565	54,054	3108	2484	23.4
11/03 - 11/22	39,841	-	1396	-	28.5
11/20 - 12/09	48,080	-	1122	-	42.9
12/08 - 01/17/87	51,737	11,463	1296	1760	20.7
1986 Overall					25.2
1987					
01/16 - 01/30	32,937	-	1987	-	16.6
01/30 - 02/17	29,291	-	1978	-	14.8
02/16 - 02/28	19,974	-	2101	-	9.5
02/28 - 03/29	38,996	-	1664	-	23.4
03/23 - 06/09	58,267	-	2100	-	27.8
06/09 - 07/05	28,630	-	2553	-	11.2
06/22 - 08/24	43,243	-	1260	-	34.3
08/13 - 10/30	73,760	-	1690	-	43.6
10/30 - 01/17/88	58,118	-	1940	-	30.0
1987 Overall					22.2
1988					
01/17 - 02/06	43,496	-	2708	-	16.1
02/04 - 03/07	13,428	-	2528	-	5.3
03/03 - 04/06	49,667	-	1396	-	35.6
04/05 - 06/25	39,403	-	1377	-	28.6
06/25 - 08/05	33,258	-	2730	-	12.2
08/01 - 09/16	19,924	-	3166	-	6.3
09/05 - 11/10	1,279	50,172	-	1710	30.1
11/07 - 12/01	-	35,970	-	1560	23.1
1988 Overall					16.7

the LLLW concentrate production. The volumes from all other sources, including contribution from rainfall, had no significant effect on concentrate production. It must be noted, however, that this regression analysis only accounts for 77% of the variability present in concentrate production from each campaign and consequently does not comprise a model of the system that alone would be adequate for LLLW system simulation or could accurately predict concentrate production.

5.2.2 Operational Variability

Operational variability also appears to have a significant effect on the volume reduction efficiency of the LLLW evaporator. Figure 5.1 shows the relationship between the VRF and the amount of dilute LLLW fed to the evaporator in a given campaign. This data is summarized in Table 5.2. As can be discerned from Figure 5.1, as a greater volume of dilute LLLW is processed through the LLLW evaporator in a given campaign, the VRF for that campaign is increased dramatically. In fact, the observed VRFs vary from a low of approximately 5.3 when 13,428 gallons of dilute LLLW is processed in a campaign to a high of 43.6 when 73760 gallons of dilute LLLW are fed.

As was mentioned in Sect. 3, the operating procedure for the LLLW evaporator calls for the evaporator to be run until the specific gravity of the LLLW concentrate reaches a value of approximately 1.25. Also, the evaporator procedure specifies that the evaporator operates at a constant level. The operating data indicate that both of these specifications cannot always be met. A certain amount of dilute LLLW feed must be available to process through the evaporator in a given campaign to allow concentration to a specific gravity of 1.25 while maintaining a safe operating level in the LLLW evaporator. If an insufficient amount of feed is available, then the evaporator is run according to evaporator level and the specific gravity target is not met. In these instances, the volume reduction efficiency for that campaign is decreased.

Over the past three years, the LLLW evaporator batch sizes have, on average, decreased. Figure 5.2 shows that since 1986 the average size of an evaporator batch has fallen from approximately 75000 gallons to slightly under 40,000 gallons in 1988. Consequently, the average volume reduction factor has fallen from approximately 25 in 1986 to approximately 16 in 1988.

5.3 RESULTS

There are two major sources of VRF variability in the operation of the LLLW evaporator:

(1) variability in the source of the feed of each evaporator batch, and

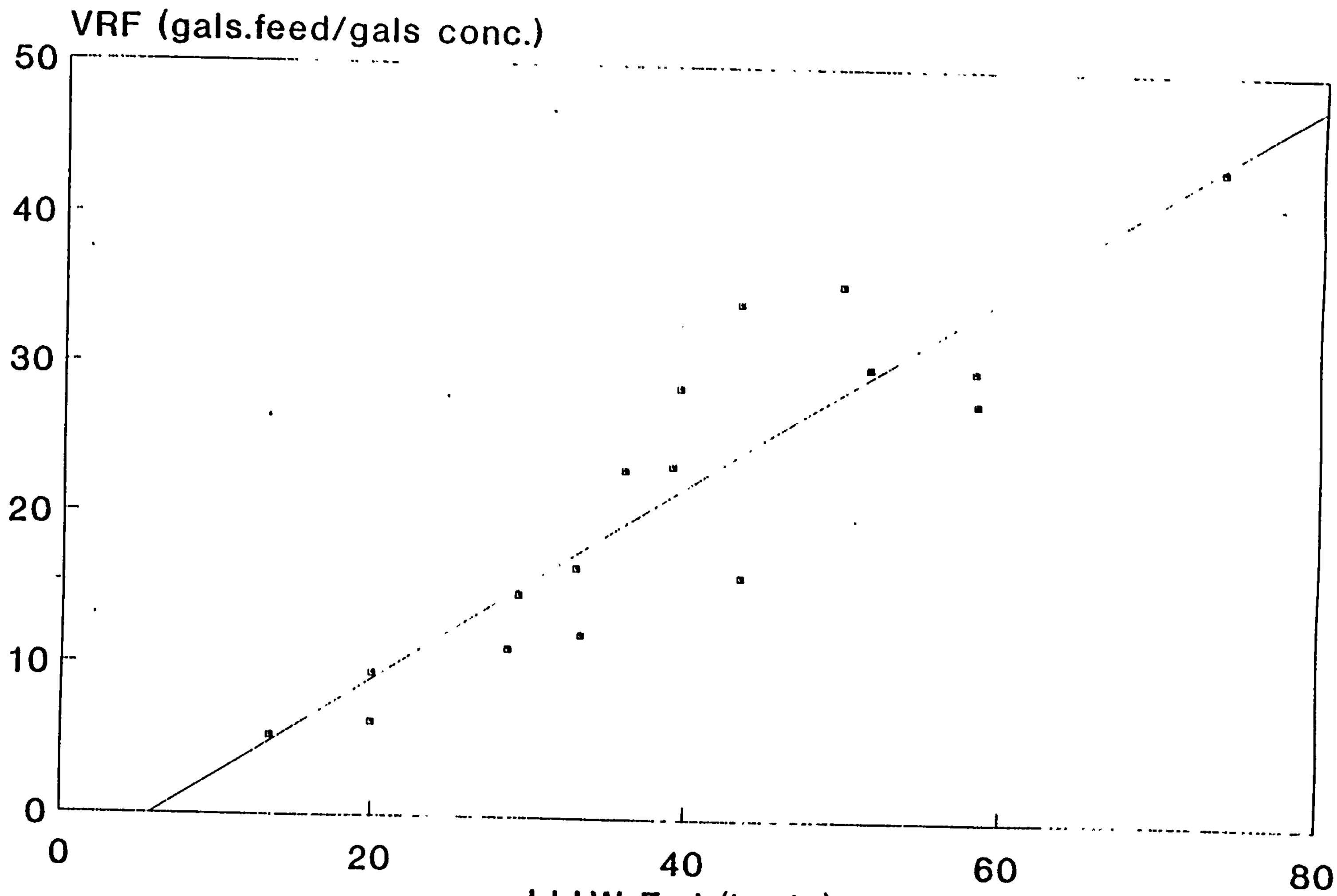

Figure 5.1. Volume Reduction Factor (VRF) as a function of dilute Liquid Low-Level Waste (LLLW) fed to the evaporator

Table 5.2. LLLW evaporator data 1987-1988.

Campaign date	Total feed (gal)	Volume reduction factor (VRF)
01/16/87 - 01/30/87	32,937	16.6
01/30/87 - 02/17/87	29,291	14.8
02/16/87 - 02/28/87	19,974	9.5
02/28/87 - 03/29/87	38,996	23.4
03/23/87 - 06/09/87	58,267	27.8
06/09/87 - 07/05/87	28,630	11.2
06/22/87 - 08/24/87	43,243	34.3
08/13/87 - 10/30/87	73,760	43.6
10/30/87 - 01/17/87	58,118	30.0
01/17/87 - 02/06/88	43,496	16.1
02/04/88 - 03/07/88	13,428	5.3
03/03/88 - 04/06/88	49,667	35.6
04/05/88 - 06/25/88	39,403	28.6
06/25/88 - 08/05/88	33,258	12.2
08/01/88 - 09/16/88	19,924	6.3
09/05/88 - 11/10/88	51,451	30.1
11/07/88 - 12/01/88	35,970	23.1

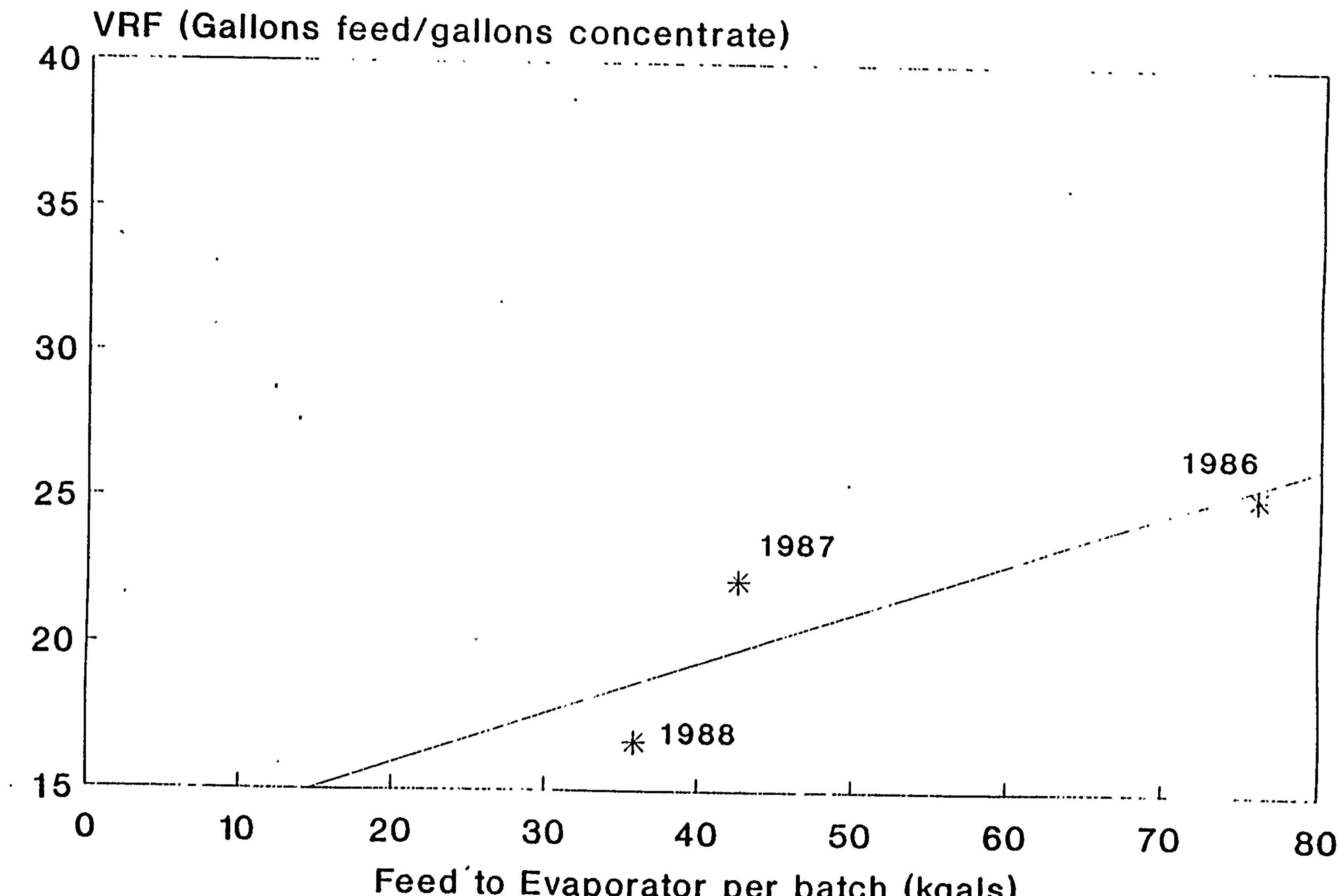

Figure 5.2. Evaporator Performance 1986-1988: Volume Reduction Factor (VRF) as a function of average feed per batch

(2) variability in the operation of the evaporator itself. As was demonstrated in Sect. 5.2.1, only two areas, the FPDL and the PWTP, are important statistically as LLLW concentrate generators. Thus, these two generators need to be targeted as areas for future sampling campaigns to characterize their waste.

After the wastes are characterized, the potential for source treatment needs to be determined. The potential savings of LLLW concentrate to be realized by the elimination of these areas from the central LLLW system is approximately 6000 gallons annually which corresponds to a cost savings of approximately $300,000 per year. The cost savings and volume reduction associated with the elimination of this LLLW concentrate will need to be compared with the cost and waste production of potential source treatment processes.

To improve the operation of the LLLW evaporator and minimize the LLLW concentrate production rate, larger evaporator batches will have to be run. If the batch size could increase to approximately 55,000 gallons of dilute LLLW, a reduction of approximately 5000 gallons of concentrated LLLW could be achieved with a cost savings of approximately $250,000 annually.

6. LLLW SYSTEM MASS BALANCE

The data obtained from generator interviews, surveys of the ORNL literature, the Liquid Waste Weekly Summary Sheets, and sampling information were entered in the LLLW data base and were analyzed and compiled to obtain a preliminary mass balance of the LLLW system. Tables 6.1 and 6.2 respectively summarize the nonradioactive and radioactive components entering the LLLW system. These tables are structured based on the stream designations shown in Fig. 6.1. The generators shown in Fig. 6.1 and the mass flows summarized in Tables 6.1 and 6.2 are intended to represent expected waste generation rates for 1989 and future years. For example, the waste production from the REDC is projected based on an increase in target processing due to new programs, and the LLLW generated in Fuel Recycle Division has been eliminated since that waste is no longer collected in the ORNL LLLW system. Inactive tanks not directly contributing waste to the active LLLW collection and transfer system and the LLLW contained in tank W-21 (PWTP concentrate) are not part of this analysis. The results of this mass balance compare favorably with previous analytical data obtained concerning the LLLW system; however, further sampling of the LLLW system will be required to verify the mass balance.

The LLLW system data indicate that there are currently or will be in FY 1990 three primary contributors of dissolved solids to the LLLW system: they are the PWTP, the FPDL, and the REDC. The PWTP and FPDL are the primary generators of nitrated waste, and the REDC is the primary generator of potassium carbonate collected in the LLLW system. These results are of particular interest since it is the dissolved solids content that primarily determines the VRF of each evaporator batch. This result compares very well with the results presented in Sect. 5.

The data presented in Table 6.2 indicate that the primary generators of radionuclides entering the LLLW system are again, the REDC and the FPDL. While small amounts of radionuclides are generated from almost every area connected to the LLLW system, over 99% of all of the radionuclides entering the LLLW system are generated at either the REDC of the FPDL. Also, the majority of the transuranic isotopes discharged to the LLLW system are generated at the REDC facility.

This data will serve as the basis for development of a long-term LLLW treatment process, to perform analyses of possible source treatment options, and to determine sampling points in the LLLW system for characterization efforts.

Table 6.1 Mass flow of nonradiological components in the LLLW system (Stream numbers refer to Fig. 6.1).

Non-radioactive Component	Stream #: 1A HFIR	1B WC-20	1 HFIR+WC-20	2 W-1A	3 WC-2	4 WC-3	5 WC-5&6	6 WC-7
Water	138000	80000	218000	73170	4133	860	7270	960
Nitric Acid	452	0.05	452.05					1
Sodium Hydroxide	1048	284	1332		6		23	7
Potassium Hydroxide		2089	2089					
Potassium Permanganate								
Potassium Carbonate		9686	9686					
Potassium Dichromate								
Acid Butyrates		0.82	0.82					
Adogen HCl		24	24					
AMSCO (pet. Naphtha)		768	768					
2,5-dibutylhydroquinone		1.1	1.1					
Diisopropylbenzene		24	24					
2-ethylhexanol		48	48					
HDEHP extractant		151	151					
HCl		146	146					1
Lithium Chloride		123	123					
Lithium Nitrate		0.07	0.07					
Mercury (II) Nitrate		3.2	3.2					
Sodium aluminate		115	115					
Sodium Thiosulfate		0.63	0.63					
Calcium Carbonate	18	10	28	10	1	1	1	1
Magnesium Carbonate	3	2	5	2	1	1	1	1
EDTA								1
Ammonium Hydroxide								
Detergents								
Alpha-hydroxyisobutyric a								
Citric Acid								
Methyl isobutyl ketone								
Oxalic Acid								
Sulfurous Acid								
Methanol								
Sulfuric Acid								
Acetone								
Hydrofluoric Acid								

Table 6.1 (Continued)

Non-radioactive Component	7 WC-8	8 WC-9	9 WC-10	10 WC-11	11 WC-12	12 W-12	13 WC-13	14 WC-14
Water	24400	15300	73200	27000	8180	84350	30300	7400
Nitric Acid			103			6		50
Sodium Hydroxide	29	6	113.9	46	75	347	61	36
Potassium Hydroxide			1					
Potassium Permanganate			27					
Potassium Carbonate								
Potassium Dichromate							1	
Acid Butyrates								
Adogen HCl								
AMSCO (pet. Naphtha)								
2,5-dibutylhydroquinone								
Diisopropylbenzene								
2-ethylhexanol								
HDEHP extractant								
HCl			1					
Lithium Chloride								
Lithium Nitrate								
Mercury (II) Nitrate								
Sodium aluminate								
Sodium Thiosulfate								
Calcium Carbonate	3	2	10	4	1	11	4	1
Magnesium Carbonate	1	1	1	1	1	2	1	1
EDTA								
Ammonium Hydroxide			1					1
Detergents			200			15	1	2
Alpha-hydroxyisobutyric a			1					
Citric Acid			11					
Methyl isobutyl ketone			1					
Oxalic Acid			33					
Sulfurous Acid						200		
Methanol							1	
Sulfuric Acid							2	
Acetone							1	3
Hydrofluoric Acid								1

Table 6.1 (Continued)

Non-radioactive Component	15 W-16	16 W-17&18	17 WC-19	18 Bldg. 3019A	19 Bldg. 3544F	20 Bldg. 2531	21 Bldg. 3039	22 Bldg. 3517
Water	18620	79260	62590	40430	29610	89500	148750	143100
Nitric Acid		1	80	29	4000			1900
Sodium Hydroxide	38	154	100		2200	255	40	140
Potassium Hydroxide		1						
Potassium Permanganate								
Potassium Carbonate								
Potassium Dichromate								
Acid Butyrates								
Adogen HCl								
AMSCO (pet. Naphtha)								
2,5-dibutylhydroquinone								
Diisopropylbenzene								
2-ethylhexanol								
HDEHP extractant								
HCl		1						
Lithium Chloride								
Lithium Nitrate								
Mercury (II) Nitrate								
Sodium aluminate								
Sodium Thiosulfate								
Calcium Carbonate	2	10	8	5	4	12	19	19
Magnesium Carbonate	1	2	1	1	1	2	3	3
EDTA								
Ammonium Hydroxide		1						
Detergents		10						230
Alpha-hydroxyisobutyric a								
Citric Acid								
Methyl isobutyl ketone								
Oxalic Acid								230
Sulfurous Acid	90							
Methanol								
Sulfuric Acid			20					
Acetone								
Hydrofluoric Acid								

Table 6.1 (Continued)

Non-radioactive Component	23 Bldg. 2026	24 Trucked	25
Water			
Nitric Acid	3820	17350	1207553
Sodium Hydroxide			6622.05
Potassium Hydroxide			5008.9
Potassium Permanganate			2091
Potassium Carbonate			27
Potassium Dichromate			9686
Acid Butyrates			1
Adogen HCl			0.82
AMSCO (pet. Naphtha)			24
2,5-dibutylhydroquinone			768
Diisopropylbenzene			1.1
2-ethylhexanol			24
HDEHP extractant			48
HCl			151
Lithium Chloride			149
Lithium Nitrate			123
Mercury (II) Nitrate			0.07
Sodium aluminate			3.2
Sodium Thiosulfate			115
Calcium Carbonate			0.63
Magnesium Carbonate	1	2	160
EDTA	1	1	36
Ammonium Hydroxide			1
Detergents			3
Alpha-hydroxyisobutyric a		20	478
Citric Acid			1
Methyl isobutyl ketone			11
Oxalic Acid			1
Sulfurous Acid			263
Methanol			290
Sulfuric Acid			1
Acetone			22
Hydrofluoric Acid			4
			1

			1233668.77

Tablo 6.2 Mass flow of radiological components in the LLLW system (Stream numbers refer to Fig. 6.1)

Radioactive Component	Stream #: 1A HFIR	1B WC-20	1 HFIR+WC-20	2 W-1A	3 WC-2	4 WC-3	5 WC-5&6
Ag-110m							
Am-241		1.7	1.7				
Am-242		1.0E-03	1.0E-03				
Am-243		0.1	0.1				
C-14							
Cf-252		0.8	0.8				
Cm-244		78.2	78.2				
Cm-246		0.2	0.2				
Co-56							
Co-58							
Co-60	5		5				
Cr-51	1.0E-03		1.0E-03				
Cs-134							
Cs-137	1.0E-03		1.0E-03				
Eu-152	1.0E-03		1.0E-03				
Eu-154	1.0E-03		1.0E-03				
Eu-155							
Fe-55							
Fe-59							
Gd-153							
H-3							
I-125							
I-129							
Ir-192							
Mixed fission prod		42000	42000				
Mn-54	1.0E-03		1.0E-03				
Ni-63							
Pm-147							
Pu-238							
Pu-239							
Pu-242							
Ra-226							
Ru-106							
Sr-85							
Sr-90							
Ta-182	1.0E-03		1.0E-03				
Tc-95m							
Tc-99							
Th-228							
Th-232							
U-233							
U-234							
U-235							
U-238							
W-188							
Zr-95							
mixed Pu		0.5	0.5				
other Cf		1.0E-03	1.0E-03				
other Cm		1.0E-03	1.0E-03				

Table 6.2 (Continued)

Radioactive Component	6 WC-7	7 WC-8	8 WC-9	9 WC-10	10 WC-11	11 WC-12	12 W-12	13 WC-13
Ag-110m				0.8				
Am-241	1.0E-07			1.0E-03				
Am-242								
Am-243				1.0E-03				
C-14								1.0E-03
Cf-252				1.0E-03				
Cm-244				1.0E-03				
Cm-246								
Co-56				1.0E-03				
Co-58								1.0E-03
Co-60	6.0E-06			3				1.1E-02
Cr-51								
Cs-134								1.0E-03
Cs-137				30			50	1.0E-03
Eu-152				1.0E-03				1.0E-03
Eu-154				1.0E-03				1.0E-03
Eu-155								
Fe-55				1.0E-03				
Fe-59				1.0E-03				1.0E-03
Gd-153				1.0E-03				
H-3				1.2E-04				1.0E-03
I-125				1.2E-03				
I-129				3				
Ir-192				3				
Mixed fission prod								
Mn-54								1.0E-03
Ni-63				1.0E-03				
Pm-147				3				
Pu-238				1.0E-03				
Pu-239				1.0E-03			1.0E-03	
Pu-242								
Ra-226								1.0E-03
Ru-106								
Sr-85								1.0E-03
Sr-90	1.2E-05			30				1.0E-03
Ta-182	1.0E-07							
Tc-95m								1.0E-03
Tc-99				3				1.0E-03
Th-228								
Th-232							1.0E-03	
U-233							1.0E-03	1.0E-03
U-234				1.0E-03				
U-235				1.0E-03			1.0E-03	
U-238							1.0E-03	1.0E-03
W-188								
Zr-95								
mixed Pu								
other Cf								
other Cm								

Table 6.2 (Continued)

Radioactive Component	14 WC-14	15 W-16	16 W-17&18	17 WC-19	18 Bldg. 3019A	19 Bldg. 3544F	20 Bldg. 2531	21 Bldg. 3039
Ag-110m								
Am-241	1.0E-03							
Am-242								
Am-243	1.0E-03							
C-14								
Cf-252								
Cm-244								
Cm-246								
Co-56								
Co-58								
60				1.0E-03		1.1E-04		1.2E-02
.. 51								
Cs-134	6.0E-02			1.0E-03				
Cs-137	0.7			1.0E-03	1.0E-03	9.1E-03		2.5E-03
Eu-152	1.0E-03					3.4E-04		3.2E-03
Eu-154						1.4E-04		1.9E-03
Eu-155						3.1E-05		6.2E-04
Fe-55								
Fe-59								
Gd-153								
H-3			1.2E-04					
I-125								
I-129								
Ir-192								
Mixed fission prod								
Mn-54				1.0E-03				
Ni-63								
Pm-147								
Pu-238	1.0E-03							
Pu-239	1.0E-03							
Pu-242	1.0E-03							
Ra-226				1.0E-03				
Ru-106				3				
Sr-85								
Sr-90				1.0E-03	1.0E-03			
Ta-182								
Tc-95m								
Tc-99								
Th-228								1.2E-03
Th-232	2.2E-06							
U-233					9.6			
U-234								
U-235					1.0E-03			
U-238	3.4E-05				6.7E-04			
W-188			1.2E-03					
Zr-95								8.8E-05
mixed Pu								
other Cf								
other Cm								

Table 6.2 (Continued)

Radioactive Component	22 Bldg. 3517	23 Bldg. 2026	24 Trucked	25
Ag-110m				0.8
Am-241				1.702
Am-242				0.001
Am-243				0.102
C-14				0.001
Cf-252				0.801
Cm-244				78.2
Cm-246				0.2
Co-56				0.001
Co-58				0.001
Co-60				8.02
Cr-51				0.001
Cs-134				0.062
Cs-137	15000	4.0E-03		15,100
Eu-152				7.56E-03
Eu-154				5.05E-03
Eu-155				6.53E-04
Fe-55				0.001
Fe-59				0.002
Gd-153				0.001
H-3				1.24E-03
I-125				1.20E-03
I-129				3
Ir-192				0.001
Mixed fission prod				42,000
Mn-54				0.004
Ni-63				0.001
Pm-147				3
Pu-238				0.002
Pu-239				0.003
Pu-242				0.001
Ra-226				0.002
Ru-106				3
Sr-85				0.001
Sr-90	20000			20,000
Ta-182				0.001
Tc-95m				0.001
Tc-99				3
Th-228				1.16E-03
Th-232				1.00E-03
U-233				9.6
U-234				1.00E-03
U-235				3.00E-03
U-238		1.0E-06		2.71E-03
W-188				2.20E-03
Zr-95				8.84E-05
mixed Pu				0.5
other Cf				0.001
other Cm				0.001

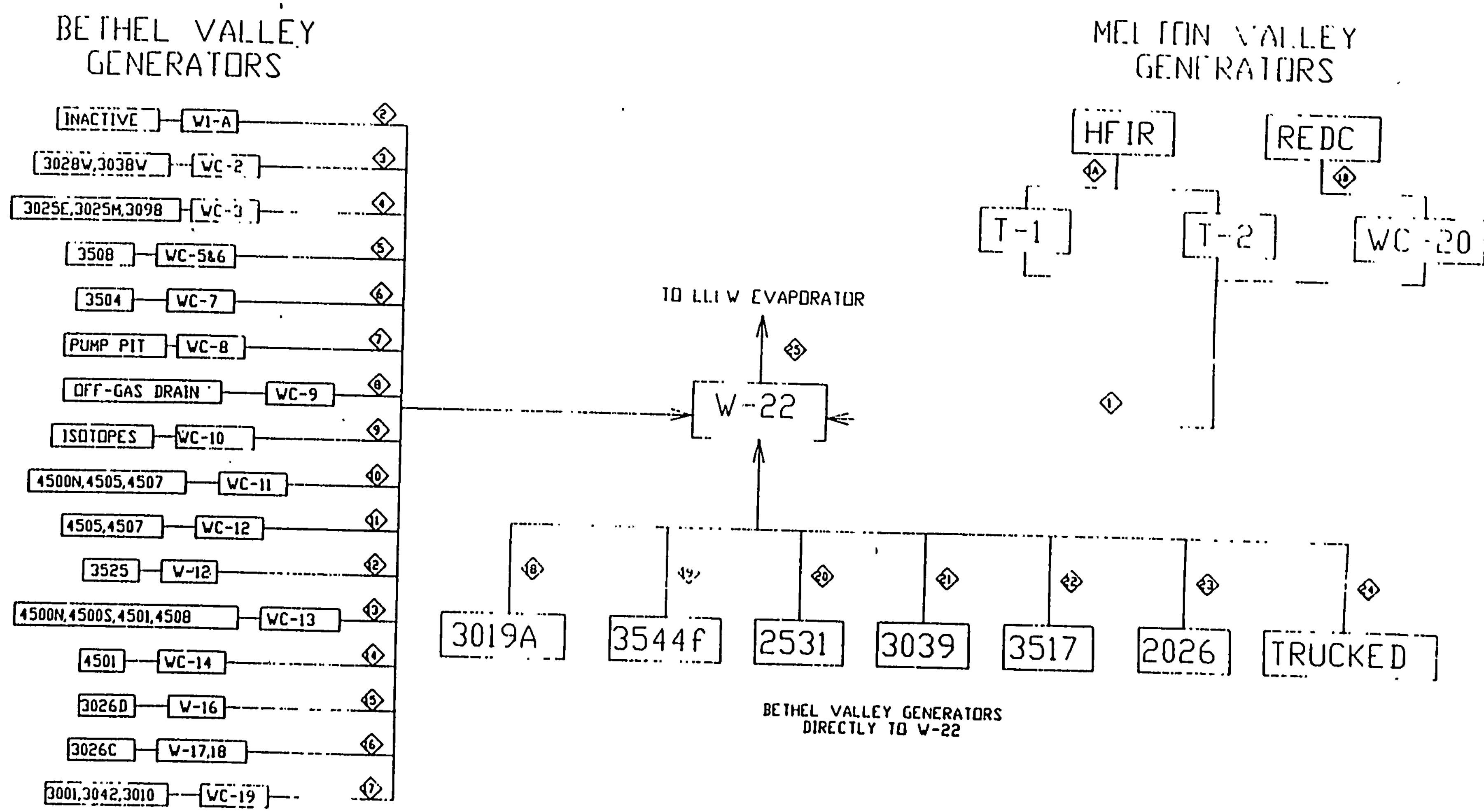

FIGURE 6.1
LLLW SYSTEM SCHEMATIC

7. CONCLUSIONS AND RECOMMENDATIONS

Figure 7.1 is a summary of the present status of the LLLW data base, i.e., the data that has been collected to date and data that is currently being obtained. It also indicates general data needed to finalize an analysis of the LLLW system. The data base is complete with respect to the following general data categories:

(1) generator LLLW volume production since 1986,

(2) generator facility descriptions,

(3) chargeback information,

(4) general LLLW system information pertaining to the physical equipment of the system,

(5) evaporator campaign data, and

(6) LLLW concentrate volumes.

Analysis of this limited data has provided the following conclusions:

(1) There are two generators that primarily affect the volume reduction factor of the LLLW evaporator: the PWTP and the FPDL. As new programs develop, the REDC will become a primary contributor to concentrate production.

(2) A significant portion of the variability observed in the VRF from evaporator batch to evaporator batch can be attributed to operational effects.

(3) Rainfall collections account for approximately 20% of the LLLW collections.

(4) There are two primary generators of the radionuclides collected by the LLLW system: The REDC and the FPDL.

(5) A working mass balance of the LLLW system has been completed.

Analytical data from the major LLLW generators and certain critical areas of the LLLW system are required before the systems analysis can be completed. Sampling of the primary generators and of the evaporator feed tank, W-22, however, is necessary to validate the mass balance completed in this study. Based on results of systems analyses to date, sampling of the REDC waste to determine the specifics of their mixed fission products stream and sampling of the FPDL when cesium and strontium production runs are being made should have top priority. Tank W-22 should be sampled routinely so that the feed to the evaporator can be well characterized and the efficiency of the evaporation process can be monitored.

Once the waste streams from the major generators are well characterized, the feasibility of source treatment at each of the major generators needs to be determined. For this work to be done effectively, a thorough understanding of each process must be gained

	Generators (Sources)	Underground Collection Tanks	Evaporator Feed Tank	Evaporator	Concentrate Storage
Data in Data Base	general info rainfall volumes composition	general info chargeback volumes limited sample analyses	volumes general info	general info volumes/VRF evaporator campaign data	general info sample analyses volumes characterization data
Data being Obtained				operating data	
Data Needed	sample analyses		sample analyses	sample analyses	ITE data

Fig. 7.1. Summary of data collection and needs.

and development work will need to be in conjunction with the generator. Current funding levels will not allow any of this work to be done.

Future work will entail the following activities:

(1) Completion of the menu-driven, user friendly data base. The data base will be designed so that a general understanding of personal computer operation will allow ready access to all LLLW system data.

(2) The LLLW system will be optimized with respect to source treatment vs. a central treatment system. To do this analysis, an estimate of the LLWDDD Class I and II disposal limits will be required.

(3) A flowsheet for centralized LLLW treatment will be developed.

(4) If funding becomes available, work is planned with the major generators to explore the different source treatment options available for their use.